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A COMPARATIVE STUDY OF THE SPEECH COORDINATIONS OF DEAF AND NORMAL SUBJECTS*[1]

From the Clarke School for the Deaf, Northampton, Massachusetts

CLARENCE V. HUDGINS

Speech of the deaf presents various degrees of abnormalities. There is no such thing as standard "deaf speech." The speech of normal individuals presents the only standard by which the speech of the deaf can be judged. It is, therefore, essential that any study of the speech of the deaf be undertaken as a comparative study in which the speech of the deaf and the speech of normal subjects are considered. The kymographic method offers one of the best means for such a study. It is possible to obtain detailed records of the speech mechanism in action. Kymographic records taken from both deaf and normal subjects show detailed differences and give us an objective measure of the degree of abnormality of the speech of deaf subjects.

In the present study a group of normal subjects and a group of deaf subjects were required to repeat phrases of different lengths while tracings from the breathing muscles and of the air pressure outside the mouth were recorded. The records were then studied in detail and comparisons were made.

*Accepted for publication by Walter S. Hunter of the Editorial Board.

[1]The experimental work of this paper was conducted at the Clarke School for the Deaf at Northampton, Massachusetts, during the school year of 1932-33. I take this opportunity of expressing my appreciation to Miss Bessie N. Leonard, Principal of the School, for her cooperation, especially in providing parts of the apparatus. It is a pleasure to acknowledge the cooperation of Miss Annette Howes and Miss Mary Numbers, teachers of the school, who managed the routine of providing subjects for the experimental groups. I am deeply indebted to Dr. Ruth Guilder and to her associate, Miss Louise Hopkins, who gave me access to their files of audiometric records and personal advice in the grouping of the subjects as to their degree of deafness. Miss Elizabeth M. Collins of the Smith College Day School provided a large number of the normal subjects from among her pupils. The entire Normal Training Class put the writer under obligations by serving as subjects. I am especially indebted to the Psychological Laboratories of Clark University and Oberlin College for the loan of valuable apparatus with which to carry out the experiments. Mrs. Ruth B. Hudgins rendered valuable assistance in measuring the records and in the statistical treatment of the data.

The Clarke School for the Deaf offers an excellent field for such a study. The school has been, since its founding, an ardent advocate of the "oral method" in teaching the deaf. Oral speech and lip reading are the only means of communication used among its pupils. It has been since its founding a leading school in its field, and the speech of its pupils may be taken as representative of pupils in such institutions

I shall present (1) a brief discussion of the normal speech co-ordinations, (2) apparatus and methods, (3) results, and (4) discussion of results.

The Normal Speech Coordinations

Normal speech consists of a series of rapid, highly skilled movements of both the breathing muscles and the muscles of articulation. These movements may be made audible by the sounds which they produce, but the movements themselves are of primary importance in any phonetic analysis. The normal speaker controls the movements of speech by the sounds produced, but cues from the movements themselves play an important rôle in this control. In the speech of the deaf, cues from the movements themselves must be the essential controlling factors since the sounds are never heard in ordinary speech

Since movements are the essential things in speech, the coordinations involved must be understood if we are to make an analysis of the speech of the deaf. Any phonetic analysis, therefore, must start with a consideration of the fundamental movements of speech, i.e., the chest pulse for the syllable, and the larger breathing movement for the phrase which groups these syllable pulses into "breath groups." A brief summary of the normal function of the speech mechanism follows.

The Speech Muscles. Figure 1 is a diagrammatic drawing of a cross-section of the trunk showing the various breathing muscles and the two principal opposing muscle groups. The first group produces the simple pulse for the syllable. The smaller chest muscles between the ribs and the direction of their fibers are indicated in the drawing by the diagonal lines between the pairs of ribs. The intercostal muscles, like most muscle groups in the body, are arranged in pairs, the members of which work in opposition. The internal intercostals (*I.I.*, Figure 1) slant diagonally downward and back-

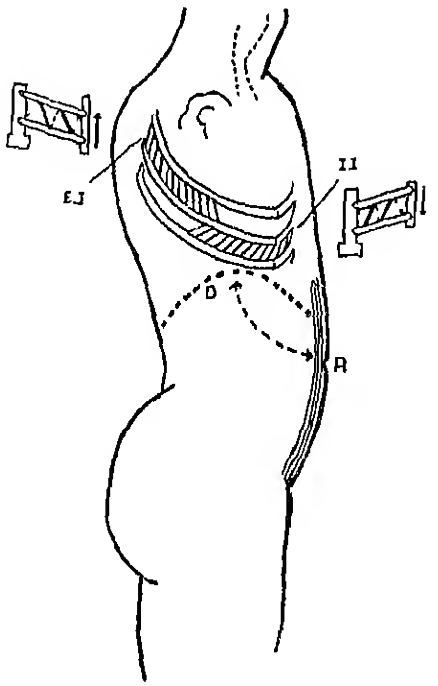

FIGURE 1

THE FUNDAMENTAL MUSCULATURES OF SPEECH

A The reciprocating muscles which produce the syllable pulse (the ribs *are exposed to show the two layers of intercostal muscles)*

I I—The internal intercostal muscles They are more pronounced near the sternum The action of these muscles rotates the ribs downward decreasing the capacity of the chest and expelling air for *the syllable pulse (Muscles of expiration)*

E I—The external intercostal muscles They are more pronounced near the spine The action of these muscles rotates the ribs upward increasing the capacity of the chest and arresting the flow of air *for the syllable puff (Muscles of inspiration)*

B. The reciprocating muscles which execute the phrasing movement and group the syllables into accented feet, or breath groups

R—The rectus abdominis is the leading muscle of the abdominal group The viscera transmits the pressure set up *by the contraction of* the abdominal group to the diaphragm (Muscle of expiration)

D—The diaphragm in cross-section When the larger muscles of the chest fixate the "rib cage" the contraction of the diaphragm enlarges *the* chest, forces *the* viscera downward, and *the abdominal* muscles outward (Muscle of inspiration)

ward; when they contract, the ribs are rotated downward, decreasing the volume of the chest cavity. They are muscles of expiration (3) The external intercostals (*E.I.*, Figure 1) slant diagonally downward and forward; when they contract, the ribs are rotated upward, enlarging the chest volume They are muscles of inspiration (3). The small mechanical models on either side of the drawing (Figure 1) indicate the action of the intercostal muscles.

The second group in opposition is the abdominal-thoracic group. The larger muscles of respiration which play an important part in speech are the abdominal muscles and the diaphragm (*R* and *D*, Figure 1) The diaphragm is a muscle of inspiration, the contraction of which enlarges the chest cavity by lowering the "floor" of the chest This action of the diaphragm is opposed by the abdominal muscles, the rectus (*R*, Figure 1), the lateral obliques, and the transverse muscles, which are not shown in the figure The abdominal muscles are, therefore, muscles of expiration. The contraction of the abdominal muscles constricts the abdomen and forces the viscera upward against the diaphragm. This action is indicated on the figure by the curved arrow.

The Chest-Abdominal Posture Speech is a modified form of breathing: the action of the breathing muscles during speech is a variant of the ordinary breathing coordination. Since speech occurs on the expiratory phase of respiration, the expiratory movement is slower than in ordinary breathing, while inspiration occurs in quick intakes of breath between phrases. The chest-abdominal posture during the phrase is worth noting. In preparation for the phrase, air is drawn into the lungs and the chest is poised in a slightly inflated position. The air in the lungs is not under pressure As the phrase starts the abdominal muscles contract slightly in advance of the syllable stroke. This anticipatory contraction of the abdominal muscles compresses the abdomen and forces the viscera upward against the diaphragm, thus providing a firm support for the action of the chest muscles. With this support from below, the expiratory muscles of the chest make quick strokes which force pulses of air upward through the trachea, these are the syllable pulses. Without this firm support of the abdominal muscles, the sudden compression of air in the chest which occurs with each syllable pulse would tend to force the diaphragm downward and the force of the syllable movement would be partly dissipated. The abdominal muscles

continue the contraction in a slow controlled movement as the phrase continues and more air is expelled. The diaphragm is forced higher within the chest while the lower part of the chest is pulled downward. The chest descends gradually, adjusting itself to the depleted air supply and to the action of the abdominal muscles. Thus a gradually changing posture is maintained throughout the phrase. As the phrase ends the large muscles of inspiration quickly inflate the chest, the diaphragm contracts, forcing the viscera downward; the abdominal muscles relax, the chest is elevated and air flows into the lungs for the next phrase

The Movement of the Syllable. The smallest unit movement of speech is the movement of the syllable This is a quick "ballistic" movement of the smaller expiratory muscles of the chest which sends a pulse of air upward through the trachea (6, 1). The movement of the consonant which releases or arrests this pulse of air cannot be considered a separate element because it occurs only as an accessory movement to the syllable itself, and has no independent existence in speech, apart from the syllable in which it functions. The attempt to produce a separate "consonant sound" results in a voiced or whispered syllable. For instance, when *b* or *p* are spoken alone they are releasing consonants of either voiced or whispered syllables *bu* and *pu* The movements of the muscles of the larynx which control the glottal slit through which the pulse of air must pass have a secondary function in the syllable, the formation of the vowel tone, but that they are not of primary importance in producing the syllable pulse is shown by the following facts: (*a*) The muscles of the larynx do not contract faster than 4 or 5 times per second (1) while the syllable may continue up to a rate of 8 to 10 per second (*b*) Laryngectomized subjects learn to make all the sounds of a language and achieve normal speech by means of an artificial larynx in which the vibrations are controlled only by the air pulses from the chest (9). The syllable movement is, therefore, the fundamental unit movement of speech

How do we know that the syllable movement is a function of the intercostal muscles? In the first place, the position of these muscles and the direction of their fibers (Figure 1) indicate that such a function is possible Furthermore, Martin and Hartwell (3) in 1879 demonstrated that the external intercostals were muscles of inspiration and that the internal intercostals were muscles of ex-

piration The high rate at which syllables may be spoken is sufficient proof that the movements are made by a group of smaller breathing muscles. It is possible to repeat syllables at a rate as high as 8 to 10 per second. Movements at this rate cannot be made by the larger abdominal muscles because of their size and the mass to be moved. At rates of utterance higher than 3 to 4 per second the abdominal muscles become fixated. *The syllable pulses can be demonstrated, however, up to the maximum speed of utterance* (7) Finally, action-current records have been obtained from the intercostal muscles which clearly indicate the reciprocal contractions of these muscles during the fixation of the abdominal muscles at the maximum rate of syllable utterance (1).

At slow rates of utterance, 1 to 3 syllables per second, the chest muscles share the syllable movement with the abdominal muscles. The abdominal muscles contract and relax with each syllable At rates higher than this the abdominal muscles fixate and provide a slow-moving postural support for the chest muscles while the latter make the syllable movements alone (7).

The Movement of the Phrase. The abdominal muscles, however, have a very important function in the speech process. Syllables rarely occur alone in normal speech, instead they are in groups or phrases. The grouping of syllables into "breath groups," or phrases, is the result of a unitary movement of the large muscles of expiration. This is a slow, controlled movement performed normally by the abdominal muscles (6, 7). The chest and abdominal muscles are so coordinated in the normal speech pattern that the smaller, high-speed movements of the syllable are superimposed upon the larger, slower movement of the abdominal muscles as "ripples" upon the larger "wave." An excellent analogy of this type of coordination is found in the movements of piano playing. The larger muscles of the arm and shoulder of the pianist support the hand and carry it across the keyboard while the smaller muscles in the forearm move the fingers in high-speed movements for the individual notes

The Movement of Accent The unitary action of the abdominal muscles not only fuses the syllables into a phonetic unit, the phrase, but it also arranges the syllables into subgroups, the rhythmic feet, within the larger phrase. The phrasing movement rises to a maximum at the point of the phrase accent on a given syllable; the subgroups, however, have secondary accent which clearly show in the chest and abdominal tracings from normal subjects.

Movement of the Consonant. The relation of the consonant movement to the syllable pulse must be briefly considered. The consonant movement, like all other movements, consists of a "beat" stroke (a movement of a member to an opposing surface) and a "back" stroke (the movement of the member away from the surface). This consonant movement has two functions in the syllable: it may either release the syllable pulse or arrest it. In releasing the syllable, the beat stroke of the consonant and the beat stroke of the chest pulse occur simultaneously. The vocal canal is closed, or constricted, by the movement of the consonant so that the action of the chest muscles compresses the air in the chest and oral cavities, then the back stroke of the consonant releases the air for the vowel, as in the syllable *pu*. In arresting the syllable pulse the function is the reverse of the releasing function. The beat stroke of the consonant occurs on the back stroke of the chest pulse. In a syllable like *up* the syllable is started by the chest muscles, but the syllable pulse is stopped, arrested, by the stroke of the consonant. The closure of the lips (beat stroke) closes the vocal canal, and the rise of the air pressure in the pharynx and chest brings the syllable pulse to a close. The next syllable does not begin until after the back stroke (opening of the lips) of the consonant. The arresting and releasing consonants are modifications of the one movement cycle. The essential things are a stroke to an opposing surface, a stroke away from that surface, and accurate timing of these strokes with the movement of the syllable. In the case of the releasing consonant the beat stroke may be delivered to the opposing surface while the member is already in contact with that surface. In the syllable *pu* the lips may be already in contact before the syllable begins, in which case the beat stroke can be demonstrated as a "pressure" stroke. In this event the back stroke which releases the air is the only apparent movement. In the arresting function the beat stroke of the consonant (closure of the lips in *up*) may be the only apparent movement; the back stroke may simply appear as a relaxation of the negative muscles and the lips may remain closed indefinitely. [For full treatment of the functions of consonants see Stetson (5, pp. 42-65).]

The syllable movement is not, however, dependent upon the accessory movement of the consonant for its release or arrest. The chest muscles themselves are sufficient to release and arrest the

syllable pulse. In the self-arrested syllable the negative muscle group (external intercostals) contracts and stops the stroke of the positive muscle group (internal intercostals). Indeed, oscillographic records of action currents from both groups of muscles taken simultaneously show clearly the reciprocal contractions of these muscles, whether or not the syllable contains consonants (1).

Apparatus

The pneumatic method of recording was used throughout the experiment A motor-driven, variable-speed kymograph, carrying a record 26 by 6 inches, was used.

In order to obtain kymographic records of the speech muscles in action, it is necessary to have the subject's body supported firmly at fixed points and to have the recording tambours supported independently Girdle pneumographs are unsatisfactory for this purpose because they encircle the trunk and the resultant tracing is a complex curve which includes movements of the various muscles within the encircled zone. Tracings from localized areas on the body wall are less ambiguous if they are made with tambours carried by supports not in contact with the subject.

In this experiment a wooden frame was constructed in which the subjects stood during the speech recording. The back upright of the frame was equipped with two adjustable bearing points (wooden blocks, *T* and *L*, Figure 2) which were adjusted to support the subject at two points, the thoracic and lumbar spine. When the subject was placed in position and the supports adjusted, the body was firmly supported so as to prevent any backward movement Another upright in front of the subject, consisting of a ½-inch pipe fitted to the edge of a 4-inch board, held the recording tambours independently of the subject. The tambours could be adjusted to any position so that any localized area on the subject's trunk could be explored and the movement of that area recorded. The two uprights were supported at bottom and top by boards and firmly braced so that no lost motion occurred which would have interfered with the recording of the speech movements. The area between the uprights was 6 feet by 26 inches. Figure 2 is a photograph of the entire apparatus with the subject in position. The entire apparatus was designed to avoid hampering the subject unduly and at the same time to fixate the trunk at critical points.

FIGURE 2

PHOTOGRAPH OF THE APPARATUS WITH A SUBJECT IN POSITION

The kymograph and the syphon aspirator are shown on the table to the left. The subject stands in position in the "frame."

T and *L* are adjustable wooden blocks for bearing points at the thoracic and lumbar spine.

AO—the face mask in position for recording air expelled from the mouth during the phrase.

CBS and *BM*—thistle-tube tambours with bosses in position on the lower sternum and mesogastric area for recording the movements of the body wall at these two points.

CE—negative pressure applicator in position in the epigastric area for recording the syllable pulses.

The recording tambours which were applied to the body wall (*CBS* and *BM*, Figure 2) were thistle tubes of the usual size, the open ends of which were covered with thin rubber dam, tightly

stretched. Cork bosses, 3 cms in length and 2 cms in diameter, were glued to the center of these diaphragms. When the subject was in position the tambours were adjusted to the body area which was to be explored. The bosses were pressed against the body wall until the rubber diaphragms were forced into the cup of the thistle tube about half the length of the bosses. Thus, as the body wall moved in and out with the normal speech movements, the bosses were moved in and out, displacing the column of air within the closed recording system. The pressure changes within the recording system were transmitted to the smoked record by means of pneumodeiks described by Hudgins and Stetson (2).

An important feature of the pneumodeik is that it is equipped with a delicate phosphor-bronze diaphragm which is permanent and does not have to be replaced like the rubber diaphragm of the Marey tambour. The constancy of the diaphragm makes it possible accurately to compare tracings of pressure changes made from day to day over a long period of time.

A negative pressure apparatus was used to record the syllable stroke of the chest muscles (7). An aluminum applicator (*CL*, Figure 2) made from a medium-sized funnel (8 cm in diameter) was shaped to fit the contour of the body wall. The edges were flattened so that a flange 1 cm in width was in contact with the body surface. The applicator was connected by means of a thick-walled rubber tube to a specially made pneumodeik (2). A second rubber tube was let into the system by means of a "T" tube and connected to a syphon aspirator which provided the negative pressure. A negative pressure of 30 to 40 cms of water is sufficient to hold the applicator firmly attached to the body wall. The metal diaphragm supports the pressure on the recording end and transmits the pressure changes to the smoked drum.

This apparatus provides a very delicate recording system. Any pulse transmitted through the tissues to which the applicator is attached is transmitted to the smoked record. It is not the bulging of the surface beneath the applicator which gives the variation in pressure; instead, the flattened edge of the applicator, slightly embedded in the yielding tissues, is thrown outward by the pulse and the partial vacuum within the applicator is increased. The recording diaphragm is thus drawn inward, moving the recording needle.

In addition to tracings of the breathing muscles, tracings were

also made of some phase of the articulatory process. Air-pressure changes inside the mouth were recorded by means of a small metal tube which was placed in the corner of the mouth, and which reached behind the point of the consonant closure. The lumen of the tube was 1 mm. in diameter. A rubber tube connected the metal tube to the recording pneumodeik. The tracing of air-pressure changes just outside the mouth (*AO*, Figure 2) was made by means of a rubber mask cut to fit the contour of the area around the mouth and connected to the recording apparatus by means of a rubber tube. This rubber "mask" was ventilated, allowing the subject to breathe and still record the pressure changes in the air expelled in speech. This is a familiar speech-recording device (4, 5). Air pressure from the nose was recorded by means of nasal "olives" made familiar by Rousselot (4) and others.

Time was recorded in 2-sec. intervals on the records by means of a Jacquet chronoscope.

METHODS

Two records were made upon each kymographic sheet. A record consists of three or four tracings of the speech movements and a time record in 2 sec. Two tracings of the movements of localized areas on the body wall were taken from all subjects, a tracing of the syllable stroke was obtained from all the male subjects used, and a tracing of the air-pressure changes, either from the inside or from the outside of the mouth.

The tracings from the body walls were made with the thistle-tube tambours and bosses. One of these tambours was placed on the lower sternum to record the movements of the rib-cage at that point, the other was placed in the mid-epigastrium to record the movements of the abdominal wall at that point. When the negative pressure apparatus was used the abdominal record was obtained from a point lower down, either in the meso-gastric or naval region. The boss tracings give an accurate tracing of the long movement of expiration during the phrase. The ratio of the actual movement of the body wall to the movement of the tracing stylus is 1/5 for both tracings.

The tracings of the syllable stroke of the chest muscles were recorded by means of the negative-pressure apparatus described above. Tracings of the syllables not only show the separate syllable strokes but they also show the rhythmic grouping of the syllables within the

phrase. The syllable stroke can be recorded from any point on the chest wall or from the abdomen. In this experiment the applicator was placed in the epigastrium for convenience in fitting the surface. When the applicator is fitted to the chest wall each individual subject requires a separate fitting due to the curved contour of the rib surfaces. In using a large number of subjects the problem is simplified if the same applicator can be used for different subjects. The syllable pulse can be easily recorded from the epigastric area (7)

The tracings of the air pressures from the inside of the mouth show the rise of air pressure in the mouth as the articulatory organ makes the consonant closure. They provide a good reference point for studying the other tracings, and show how individuals handle mouth pressures for voiced and unvoiced consonants

Tracings of the air pressure outside the mouth were made simultaneously with most of the records. These tracings show a straight line for the consonant closures and a rapid rise for the vowels. They provide excellent material for studying the articulation of the various subjects; they also provide reference points for the study of the other tracings.

The following test materials were used: (*a*) A nine-syllable phrase: "Bill paid Paul the price of the pony." (*b*) A seven-syllable phrase "Bobby, don't boo at baby." (*c*) Phrases of four and five syllables containing the same syllable repeated with a fixed accent on one syllable such as. *pup pup pup' pup* (the accent was placed on different syllables during the tests) (*d*) Single syllables spoken at normal rates using both the voiced and unvoiced sounds of the same consonant, alternated, such as: *pup, bub, tut, dud, fuf, vuv;* etc.

The test materials were printed on cards and placed so that the subject could read them as he spoke. Each subject was allowed to practice until he became familiar with the phrases before any actual recording began.

The deaf subjects were all pupils of the Clarke School for the Deaf at Northampton, Massachusetts. All of the pupils in the grammar department and the three upper grades in the intermediate department were used. Sixty-two subjects were used in all, 30 girls and 32 boys The ages ranged from 11 to 20 years at the time the records were taken

The deaf subjects were divided into three groups (A, B, and C)

according to their degree of deafness as determined by the 2A Audiometer. Group A consists of 10 hard-of-hearing pupils, two boys and eight girls, ranging in age from 11 to 19 years The individuals in this group have a hearing-loss of not more than 45 decibels Eight of them are classified as "born deaf" Group B is composed of a group of 12 pupils, six boys and six girls, ranging in age from 13 to 20 years Eleven of this group are classified as "born deaf" They have a hearing-loss of not more than 70 decibels. Group C is the largest group. It consists of 24 boys and 15 girls ranging in age from 13 to 19 years. Ninety per cent of them were either born deaf or became deaf before the age of two years They all have a hearing-loss of 70 decibels or over Three subjects of this group became deaf at the ages of 8 to 10 years, their records are included with the others of Group C

All of these subjects have been in schools for the deaf as much as two years and most of them have been in such institutions since five or six years of age. They have been taught speech and lip-reading along with their other studies and are not allowed to use any other form of communication.

The subjects were not hampered by the apparatus; after a brief training period the deaf subjects learned to speak "naturally" with all the parts adjusted. Each subject returned for at least two experimental periods of half an hour each, not less than 15 phrase records were obtained from each individual. The subjects were brought into the experimental room and shown the apparatus one at a time. Each was told merely that the purpose of the experiment was to "find out how you talk."

The normal group consisted of 25 children and adults, ages ranging from 10 to 28 years; 12 males and 13 females The group consisted of boys and girls from the Smith College Day School, the Normal Teachers Training Class of Clarke School, and several adult friends of the writer All of them knew the purpose of the experiment.

The records were measured for length of the phrases (time) and the amplitude of the phrasing movements of both the chest and the abdominal tracings. The amplitude of these tracings, i.e., the perpendicular distance between the point on the tracing when the phrase begins when the lungs are inflated, to the lowest point reached in the expiratory movement for that phrase, is taken as a relative

measure of the amount of breath expelled during the phrase. The amplitude was measured in millimeters. Since two phrasing tracings were made simultaneously the mean amplitude of these two tracings was taken as the measure. The sum of these two measures might well have been used since they represent deflation of the lungs by two distinct sets of muscles, i e, the abdominal diaphragmatic opposition, and the intercostals. But the mean is equally reliable as a measure since either measure must represent the relative and not the absolute quantity of breath used Two thousand phrases were measured The phrase measurements, time and amplitude, were treated *separately for each phrase length and for each separate group of* subjects

In addition to the time and amplitude measurements it became desirable to obtain a measure of the rate of air flow per second per syllable. In order to obtain such a measure both the time and the amplitude must be included and also the number of syllables in the individual phrase. The following method was used The *amplitude of the individual phrases was divided by the time for that* phrase. The quotient was then divided by the number of syllables The formula may be represented thus: $\dfrac{A/T}{N}$. A is the amplitude, T is time, and N is the number of syllables in the phrase. The *simplified formula appears as A/TN. This indicates the rate of air* flow (movement of body walls) per second during the syllable. It will be called, for convenience, the "expiratory index," or EI.

The figures shown in the experimental section are photographs of the kymograms made by using the "black sheets" themselves as negatives The background has been cleared by retouching in some cases but in no case have the tracings themselves been retouched.

Results

Records from individuals of the several groups of subjects will be presented first and discussed in order to show the various types of coordinations found. These will be followed by a statistical summary of the quantitative data obtained from the large group of records studied

The Phrasing Movement. The phrasing movements of the normal group show a rather uniform type of *coordination for all the*

phrases used There is a quick intake of breath which is followed by a gradual inward movement of the chest and abdominal walls. The time required for the repetition of each phrase and the amplitude of the phrasing movement shows a small range of distribution for the entire normal group. (See Figures 18 and 19.) The records from the three groups of deaf subjects, on the other hand, show a great deal of variability both in the time required for the phrases and the amplitude of the phrasing movements. There are two general types of phrasing coordination found among the deaf subjects: First, the entire phrase assigned may be spoken on a single breath, in which case the tracings from the abdominal and chest walls have a very large amplitude indicating extremely large expenditure of breath for that phrase. Secondly, the phrase may be broken up into smaller phrasing movements, which means that the subject was unable to repeat the entire phrase on a single breath This is especially true for the nine- and the seven-syllable phrases Sample records from normal and deaf subjects will clearly illustrate these types of phrasing movement

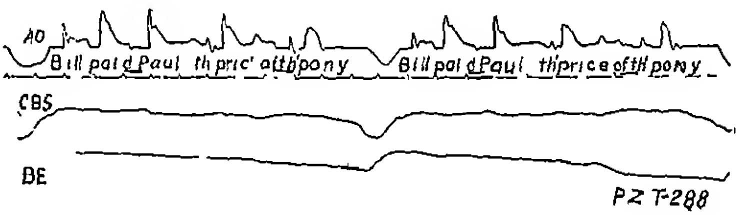

FIGURE 3

KYMOGRAM OF THE NINE-SYLLABLE PHRASE SPOKEN BY A NORMAL SUBJECT, TEN-YEAR-OLD GIRL

AO—tracing of the air pressure just outside the mouth The straight-line portions of the tracing indicate the consonants, the rise between consonants indicates the vowel Inspiration is indicated by the "dip" in the tracing between phrases

CBS—tracing of the movement of the chest wall taken from the lower sternum The movement is smooth and regular for the first phrase with a slight irregularity in the second

BE—tracing of the movement of the abdominal wall taken at the epigastric level The long slow movement of the phrase is clear The second phrase shows a slight irregularity in the latter part

Time is recorded in 2 sec

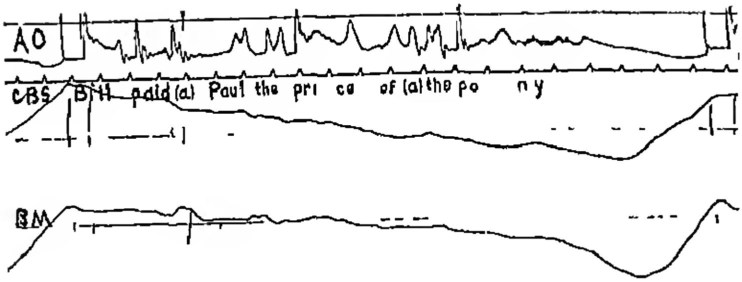

FIGURE 4

KYMOGRAM OF THE NINE-SYLLABLE PHRASE SPOKEN BY A DEAF BOY (GROUP B), AGE 16 YEARS

AO—tracing of the air pressure just outside the mouth Extra syllables are added at two points in this phrase "pai da Paul" and "o va the pony"

CBS—tracing of the movement of the chest wall taken at the lower sternum The movement is somewhat larger than the normal phrasing movement

BM—tracing of the movement of the abdominal wall taken at the epigastric level

Time is recorded in 2 sec.

Figure 3 is a record of the nine-syllable phrase spoken by a normal hearing girl, age 10 years. The time required for each of the phrases is 2.2 secs. The average time for the entire normal group for this phrase was 2.4 secs. There is a slight irregularity in the tracings from the body wall in the second phrase, but the movements on the whole are uniform. The amount of descent of the tracings *CBS* and *BE* is an indication of the relative amount of breath expelled for the phrase. Figure 4 is a record of the same phrase spoken by a partially deaf boy, age 16 years, Group B. In contrast to Figure 3, the time required for this phrase is 3.2 secs., and the irregularity of the tracings *CBS* and *BM* is noticeable. The amplitude of the expiratory movements for the phrase is larger than that of the normal subject in Figure 3. Instead of nine syllables the subject actually speaks a phrase of eleven syllables since he adds two extra syllables to each phrase. The phrase as spoken by this subject becomes: "Bill pai da Paul the price o va the pony." The *AO* tracing shows the prolonged vowels and the heavy aspiration of breath at the release of each consonant.

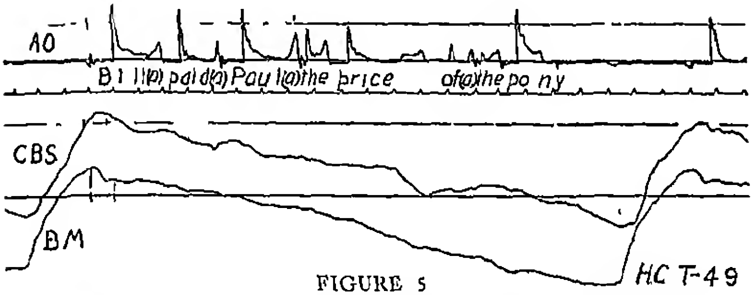

FIGURE 5

KYMOGRAM OF THE NINE-SYLLABLE PHRASE SPOKEN BY A VERY DEAF MALE (GROUP C), AGE 15 YEARS

AO—tracing of the air pressure just outside the mouth The subject is using only releasing consonants as is indicated by the addition of extra syllables between abutting consonants The sharp rise at the release of each consonant indicates the high aspiration of breath

CBS—tracing of the movement of the chest wall taken at the lower sternum The movement for the entire phrase is extremely large and irregular, lacking the smoothness of the normal subject (Figure 3)

BM—tracing of the movement of the abdominal wall taken at the mesogastric level The movement is slow and irregular, indicating undue tension in the rectus muscle The large amplitude of these two phrasing movements indicates the excess amount of breath used for the phrase.

Time is recorded in 2 sec

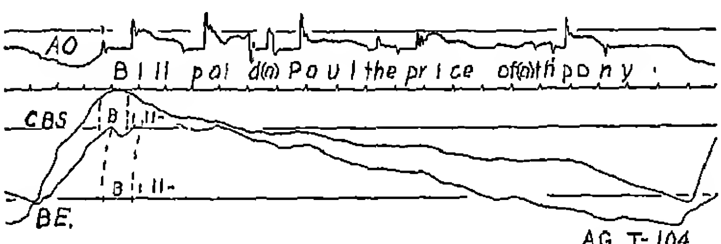

FIGURE 6

KYMOGRAM OF THE NINE-SYLLABLE PHRASE SPOKEN BY A VERY DEAF MALE (GROUP C), AGE 19 YEARS

AO—tracing of the air pressure just outside the mouth Extra syllables are added at two points in the phrase as indicated by the vowel in parentheses below the tracing

CBS—tracing of the movement of the chest wall at the lower sternum The long descent and the amplitude of the movement indicate the abnormal amount of breath used for the phrase

BE—tracing of the movement of the abdominal wall at the epigastric level The rate of descent of this tracing is greater than that of the chest tracing

Time is recorded in 2 sec

The very deaf subjects (Group C) still further exaggerate the movements of expiration in the execution of the phrase, as is indicated by the tracings in Figures 5 and 6 Each of these subjects require 4 secs for the phrase Each of the tracings *CBS* and *BE* (or *BM*) show that the muscles are under heavy tension. There are small "tremor" movements throughout the tracings. The amplitude of the movements is extremely large for this phrase, which indicates that a great deal more breath is being used by these subjects than was used by the normal subject In each of these records extra syllables are added to the phrase at points between abutting consonants, and the phrase is spoken: "Bill pai da Pau la the price o va the pony."

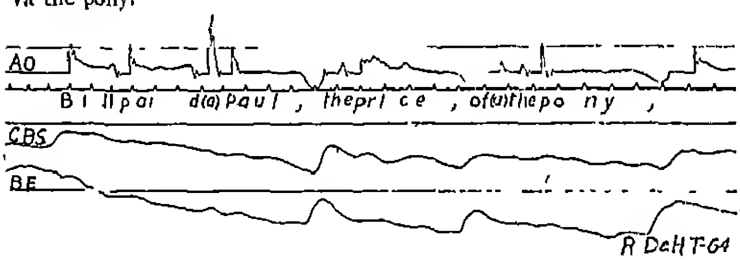

FIGURE 7

KYMOGRAM OF THE NINE-SYLLABLE PHRASE SPOKEN BY A DEAF BOY (GROUP C), AGE 13 YEARS

AO—tracing of the air pressure just outside the mouth The subject breaks the long phrase into three distinct short phrases. The intake of breath for each phrase is indicated by the "dips" below the base line between phrases.

CBS—tracing of the movement of the chest wall at the lower sternum Three short phrasing movements are indicated in this tracing The sudden rise corresponding to the intake of air is followed by the more gradual movement of expiration.

BE—tracings of the movement of the abdominal wall at the epigastric level The three phrasing movements are clearly indicated

Time is recorded in 2 sec

Figures 4, 5, and 6 were all spoken on a single breathing (phrasing) movement. Figure 7 shows a type of speech characterized by a lack of phrasing, which is rather common among the very deaf subjects In Figure 7 the same phrase (nine syllables) is broken up into three smaller phrases. The entire phrase requires 5 secs. The drop below the base line in tracing *AO* indicates the points at which the subject replenished his breath supply. Corresponding

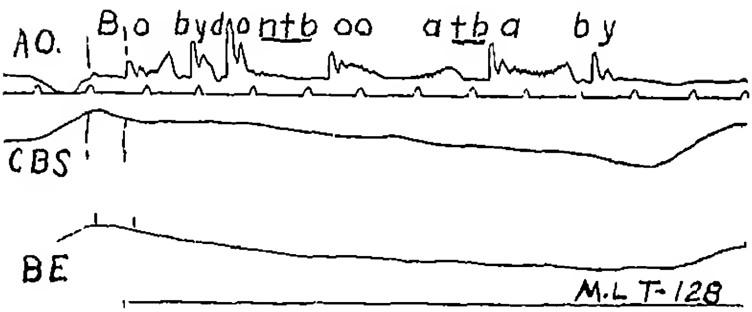

FIGURE 8

KYMOGRAM OF THE SEVEN-SYLLABLE PHRASE SPOKEN BY A HARD-OF-HEARING GIRL (GROUP A), AGE 14 YEARS

AO—tracing of the air pressure just outside the mouth No extra syllables occur, the tracing is similar to that of the normal subject (Figure 3)

CBS—tracing of the movement of the chest wall at the lower sternum. Note the smooth descent of the movement The amplitude is small, indicating that the phrase is spoken with a minimum breath expenditure

BE—tracing of the movement of the abdominal wall at the epigastric level *BE* and *CBS* have the same small amplitude

Time is recorded in 2 sec

points on the tracings *CBS* and *BE* also indicate the end and the beginning of a new breathing movement. Extra syllables are added to the phrase at points indicated below the tracing *AO*.

A somewhat more normal type of speech is represented by Figure 8, a record of the seven-syllable phrase spoken by a hard-of-hearing girl, 14 years of age, Group A. The tracings *CBS* and *BE* show the smooth easy coordination which characterizes normal speech No extra syllables occur between the abutting consonants The phrase is spoken "Bobby, don'*tb*oo a*tb*aby." The time required for the phrase is 2.0 secs.

From the above records it is clear that the deaf child shows a type of breathing movement in the execution of a given phrase which results in a very extensive loss of breath. The immediate results of this type of speech are that it becomes labored, arhythmic, and "breathy" The vowels are prolonged and in consequence mutilated. The addition of extra syllables to the given phrase adds to the difficulty of comprehending the meaning of the phrase.

It is possible to account for some of the excess loss of breath in

three ways: (*a*) The prolongation of the vowel requires more breath than is used when the vowel is spoken normally and the speech is more difficult to understand because the vowel is mutilated by prolongation (*b*) The adding of extra syllables at points where consonants abut between syllables adds to the breath expenditure and introduces extra elements to the rhythmic grouping of syllables within the phrase. (*c*) The high chest pressure with which the deaf speak leads to an excess expenditure of breath at the release of each consonant. This is indicated by an abnormally high aspiration of air before the vowel begins. (See *AO* tracings, Figures 4, 5, 6, and 7.) This high air pressure in the chest not only adds to the loss of breath but it makes the speech breathy.

These abnormalities of phrasing are directly correlated with the degree of hearing loss. The length of time required for a given phrase, the amount of breath expelled during the phrase, and the other defects mentioned all increase in severity with an increase in hearing-loss. (See Figures 18 and 19 and *Statistical Summary of Phrase Data,* pp. 34-43.)

Rhythmic Grouping of Syllables in the Phrase The grouping of syllables in the phrase and the amount of stress upon individual syllables determine the speech rhythm The rate of utterance is also a large factor in rhythm; syllables spoken at a slow rate lose all semblance of rhythm and such speech becomes monotonous. The grouping of syllables into rhythmic feet is rather clear cut in spoken English; unusual forms of grouping, misplaced accents, and slow, labored utterance constitute imperfect speech which is very difficult to understand The deaf subjects studied in this paper are inclined to do all three of these things. Those who have even a small amount of residual hearing are able to attain a rhythmic flow which is more like that of normal speech than that of the extremely deaf group. Those subjects who lost their hearing after they had learned to talk, even though the loss is practically complete, retain their normal speech rhythm and speak with a fluency which is never found among the congenitally deaf. This is good evidence for the fact that rhythm is not a question of sounds but rather one of movement, the control of which may continue when the perception of the sounds produced by those movements no longer occurs. A study of the kymographic records will show something of the rhythmic grouping among the individuals of the several groups studied. The tracing of the syllable pulse as recorded by the negative pressure applicator (*CE*) gives an excellent record of the syllable grouping.

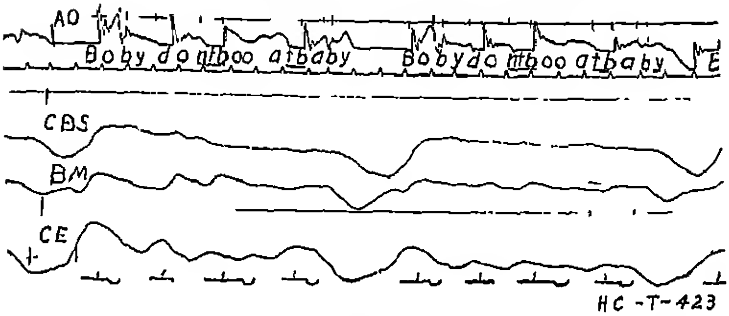

FIGURE 9

KYMOGRAM OF THE SEVEN-SYLLABLE PHRASE SPOKEN BY A NORMAL HEARING BOY, AGE 13 YEARS

The record shows the normal rhythmic grouping of syllables in the phrase

AO—tracing of the air pressure just outside the mouth. Note the straight line for the abutting consonants *-ntb-* and *-tb-*

CBS—tracing of the movement of the chest wall taken at the lower sternum. The form is regular

BM—tracing of the movement of the abdominal wall at the mesogastric level The tracing shows the word accents

CE—tracing of the individual syllable pulses in the phrase taken at the epigastric level The grouping of the syllables into rhythmic feet is clearly indicated. The symbols below the tracing indicate the rhythm

Time is recorded in .2 sec

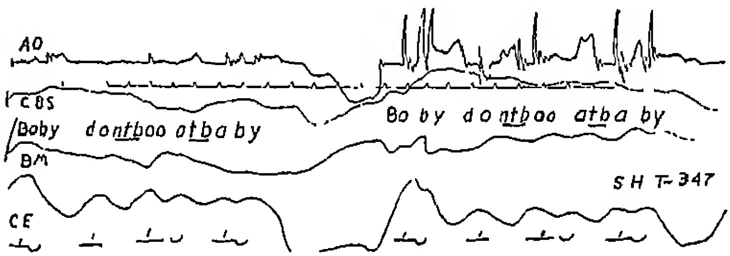

FIGURE 10

KYMOGRAM OF THE SEVEN-SYLLABLE PHRASE TAKEN FROM A PROFOUNDLY DEAF BOY, AGE 14, WHO LOST HIS HEARING AT THE AGE OF 10 YEARS

AO—tracing of the air pressure just outside the mouth This tracing for the first phrase is not clear because the subject did not hold the "mask" tightly on the face

CBS—tracing of the movement of the chest wall taken at the lower sternum The movements were irregular but of low amplitude.

BM—tracing of the movement of the abdominal wall taken at the mesogastric level The syllables are indicated in this tracing.

CE—tracing of the syllable pulses taken at the epigastric level The grouping of the syllables is clear, the rhythm is normal

Time is recorded in .2 sec

Figure 9 is a kymographic record of the seven-syllable phrase: "Bobby, don't boo at baby." The phrase was spoken by a boy of 13 years with normal hearing. The phrasing movements, *CBS* and *BM*, are normal; there is some indication of the syllable strokes in *BM*. The phrases were spoken at normal speed (ca. 2.2 secs. per phrase). The grouping of the syllables is shown in the tracing *CE* The uniformity of the syllable grouping in this tracing for the two phrases recorded here is apparent The rhythm of the phrase is –′ – –′ –′ – –′ –, with the heavier accent on the initial syllable as indicated by the extent of the syllable stroke.

Figure 10 is a kyomgram of the same phrase spoken by a deaf boy 14 years of age, who lost hearing at the age of 10 The tracings of the phrasing movements are slightly irregular and the time is somewhat slower than that of the two normal subjects (2.4 secs), but the rhythmic grouping of the syllables (*CE*) is identical with that of the normal subject in Figure 9 Figure 11 is another record of the seven-syllable phrase taken from a male subject, age 16

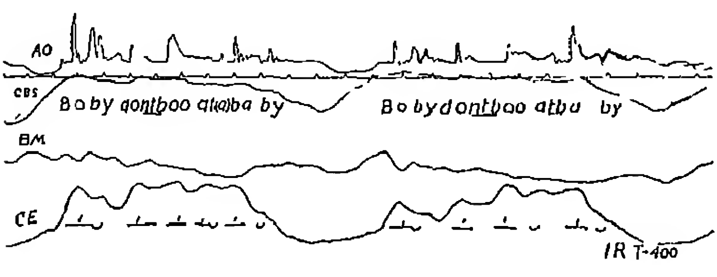

FIGURE 11

KYMOGRAM OF THE SEVEN-SYLLABLE PHRASE SPOKEN BY A PARTIALLY DEAF BOY (GROUP B), AGE 16 YEARS, WHO BECAME DEAF AT THE AGE OF THREE AND ONE-HALF YEARS

AO—tracing of the air pressure taken just outside the mouth The subject adds an extra syllable in the first phrase "a ta baby"

CBS—tracing of the movement of the chest wall taken at the lower sternum The tracing is normal

BM—tracing of the movement of the abdominal wall taken at the mesogastric level. The syllable pulses are dimly indicated in the tracing

CE—tracing of the syllable pulses taken at the epigastric level. The grouping of the syllables is clearly shown in this tracing The rhythm is normal with the exception of the extra syllable in the first phrase. The final syllable in each phrase is weak

Time is recorded in .2 sec.

years, who became partially deaf (Group B) at the age of 3 ½ years. The tracings of the phrasing movements are normal, *BM* reflects the syllable strokes *CE* shows the grouping of the syllables; in the first phrase the subject added an extra syllable which modified the rhythm, but in the second the rhythm is normal. The time required for the phrase is also normal, 2.0 secs.

Figure 12 shows a phrase in which the syllable grouping is normal, but the phrase accent is abnormally heavy. The phrase was spoken by a 16-year-old boy, Group B, classified as "congenitally deaf." There is an extra syllable added to the second phrase in the figure. This phrase was spoken –′ - -′ -′ - - -′ - The fourth syllable in each phrase has an extra heavy accent which is indicated

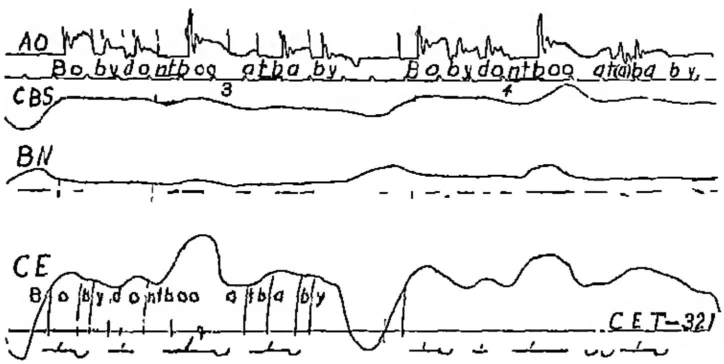

FIGURE 12

KYMOGRAM OF THE SEVEN-SYLLABLE PHRASE SPOKEN BY A DEAF BOY (GROUP B), AGE 16, SHOWING THE GROUPING OF THE SYLLABLES IN THE PHRASE

AO—tracing of the air pressure just outside the mouth The tracing is nearly like those from normal subjects, in phrase 4 the subject added an extra syllable between the words "at (a) baby"

CBS—tracing of the movement of the chest wall taken at the lower sternum There is only a slight movement for the entire phrase The heavy phrase accent is shown in this tracing

BN—tracing of the movement of the abdominal wall taken at the navel level. The movement is of small amplitude with the heavy phrase accent showing.

CE—tracing of the syllable pulses taken at the epigastric level. The rhythmic grouping in the phrase is that of normal speech with the exception of the abnormally heavy accent on the fourth syllable in each phrase.

Time is recorded in 2 sec

by the amplitude of the syllable stroke The time is that of normal speech.

In contrast to Figures 9 and 10, which are the normal phrase

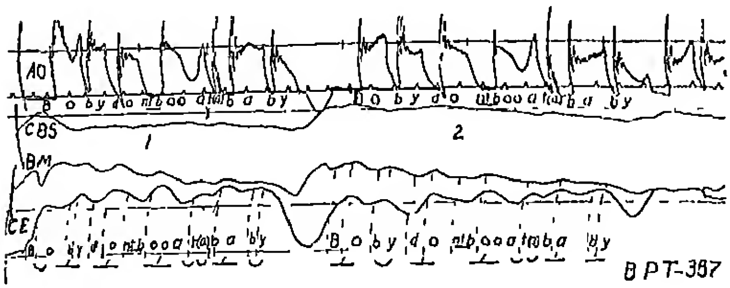

FIGURE 13

KYMOGRAM OF THE SEVEN-SYLLABLE PHRASE SPOKEN BY A DEAF BOY (GROUP C), AGE 13, SHOWING THE RHYTHMIC GROUPING OF THE SYLLABLES

AO—tracing of the air pressure just outside the mouth Note the heavy aspiration of breath for the vowels Extra syllables are added at one point in each phrase.

CBS—tracing of the movement of the chest wall taken at the lower sternum level. The movements are smooth and regular

BM—tracing of the movement of the abdominal wall taken at the meso-gastric level. The syllable pulses are reflected in this tracing

CE—tracing of the syllable pulses taken at the epigastric level Each syllable receives practically the same stress, the speech is very monotonous.

Time is recorded in .2 sec.

rhythms, Figures 13 and 14 represent the type of speech rhythms found in the extremely deaf group. Figure 13 is a kymogram of the seven-syllable phrase spoken by a congenitally deaf boy of 13 years (Group C) The heavy aspiration of breath after each consonant is indicated in tracings *AO* Extra syllables are added at one point in each phrase. The syllable grouping is as follows. - -′ -′ -′ - - -′ -. The time for each of the two phrases is above the normal time for this phrase, 2.8 secs. Figure 14 is a record of the same phrase spoken by a male subject, Group C, age 19 years The syllabic grouping is different from any of the records presented above. Two extra syllables are added to each phrase at points where two consonants abut (See tracings *AO* and *CE*) The rhythm of the phrase as indicated by the *CE* tracing is. - -′

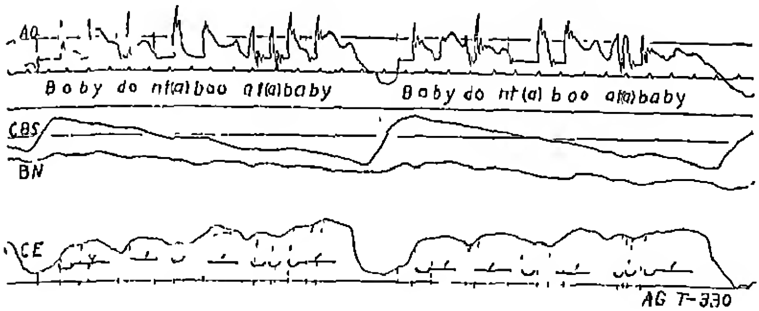

FIGURE 14

KYMOGRAM OF THE SEVEN-SYLLABLE PHRASE SPOKEN BY A DEAF MALE (GROUP C), AGE 19, SHOWING THE GROUPING OF THE SYLLABLES IN THE PHRASE

AO—tracing of the air pressure just outside the mouth The subject adds two extra syllables to each phrase at points indicated below the tracing. The height of the rapid rises in the tracing indicates the high pressure which the subject is using

CBS—tracing of the movement of the chest wall at the lower sternum The amplitude of the movement is high, indicating, further, the excess amount of breath used for the phrases

BN—tracing of the movement of the abdominal wall taken at the navel level. The movement is small in comparison to the chest at this point

CE—tracing of the syllable pulses taken at the epigastric level The individual syllables are clearly shown including the two extra syllables which the subject adds The rhythm of the phrase is indicated by the symbols below the tracing The last syllable in the phrase receives the greatest stress

Time is recorded in .2 sec

—' - —' ‿ - - —'. The heaviest accent occurs on the final syllable in each phrase. The time for each phrase is about 3 secs

Rhythm is often looked upon as a matter of sound but rhythm is surely not confined to sound. Sounds can arouse rhythms and can be grouped rhythmically, but rhythm has a far wider field than sound alone. Rhythm essentially consists of the grouping of movements about a main movement, which is said to be the accent There is nothing, therefore, about speech rhythms that the deaf cannot learn. Pitch and the voiced elements of speech are difficult for the deaf because they are dependent for the most part upon the perception of sounds, but accent and the grouping of syllables which are not dependent upon sounds can be achieved by the deaf It is necessary, therefore, that the deaf child be taught from the very be-

ginning the normal rhythms of speech and the grouping of syllables into phrases with accents. The lack of fluency in the speech of the deaf subjects studied in this paper forbids any semblance of normal rhythms as they occur in speech. But the fact remains that syllables are grouped about an accent. The grouping is an unusual one and in some cases not unlike that often heard among foreigners learning English, they may have the correct sounds for the words but lack English rhythm. Such speech is difficult to understand.

The Movement of the Consonant in the Speech of the Deaf. The importance of the proper function of the consonant movement and the consequences of the failure to recognize the arresting and releasing function of consonants in speech stand out rather clearly in the speech of the deaf. The failure to distinguish between the releasing and the arresting consonant is one of the major defects in the speech of the deaf subjects studied in this paper. Among the results of such a defect are extra syllables, either vocalized or whispered, added to the phrase, waste of breath as a result of the extra syllable between two abutting consonants; an increase in the time required for the repetition of a given phrase; breaking-up of the normal rhythm of the phrase with its effect upon the intelligibility of their speech.

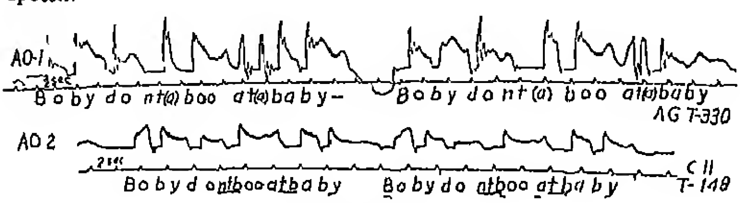

FIGURE 15

COMPOSITE KYMOGRAM OF AIR-PRESSURE TRACINGS JUST OUTSIDE THE MOUTH DURING THE SEVEN-SYLLABLE PHRASE

The upper tracing (*AO-1*) was taken from a very deaf subject (Group C) and the lower tracing was taken from a normal adult speaking the same phrase

AO-1—the tracing from the deaf subject shows the heavy aspiration of breath following the release of consonants and extra syllables added at points indicated below the tracing The subject was using only releasing consonants

AO-2—the tracing from the normal subject shows that the phrase was spoken with less aspiration of breath for the vowels. Straight lines in the tracing indicate that the abutting consonants were properly handled; no extra syllables were added at these points

Time is recorded in .2 sec.

Figure 15 contains two tracings of the air just outside the mouth for the same phrase (the seven-syllable phrase used throughout the study). The upper record was obtained from a deaf subject (Group C), with a simultaneous time record in .2-sec. intervals. Immediately beneath it is the record of the same phrase, with the time record, spoken by a normal subject It will be observed that an extra syllable appears between the third and fourth and between the fifth and sixth syllables in the upper record In the normal record, just below it, there are no extra syllables; the tracing at those points becomes a straight line during the closures of the consonants *-ntb-*, and *-tb-* The lips close in preparation for the back stroke of the releasing *b-* in both cases while the tongue is still in position for the arresting *-t*, consequently no breath is allowed to escape between them. It is of interest to note the difference in length of the two consonant groups in the upper and lower records. In the upper record *-ntb-*, with the vowel between them, required 4 sec, while the same sounds in the lower record required about 2 sec. Aside from the loss of time in the upper record at these two points, the deaf subject is really adding two extra syllables to the phrase Frequently these extra syllables are vocalized. The subject has not learned the releasing-arresting functions of consonants. Every consonant in the phrase is a releasing consonant as he utters it.

In order to have normal speech it is essential that the releasing-arresting function of the consonant be mastered. The boundaries of syllables in spoken English often fall between the arresting consonant of one syllable and the releasing consonant of the next. When both of these consonants are given as releasing consonants an extra syllable occurs between them When two syllables are joined by linking consonants which are identical they are said to be *double consonants*, as in "boo*k*case," "tha*t* *t*able," "so*me* *m*onev," etc. When the two consonants which join two syllables are different they are said to be an abutting pair, as in "fi*ft*een," "blac*kb*oard," "goo*d* *m*orning," etc Frequently consonants appear in pairs or even in three's which are neither doubles nor abutting consonants, the entire group functions as a single consonant either in the releasing or in the arresting position Such sounds are said to be compound consonants, as in "*str*eet," "*bl*ack," "*stamp*," "a*pt*," etc Compound consonants function as a single consonant movement, the time required for them is well within the range of that required for single

consonants. [See Rousselot (4, vol II, pp. 919-968) and Stetson (7, pp 119-134).] Double consonants and abutting pairs require more time (nearly double the time for single consonants) and consist of two distinct movement cycles although the back stroke of the arresting member appears as a relaxation of the muscles; and the beat stroke of the releasing member of the pair is made while the articulatory member is in contact with the opposing surface (5, pp 65-119).

Frequently the meaning of an entire phrase depends upon the proper handling of the consonants In the phrases *an aim*, and *a name*, the sounds used are identical. The meaning depends upon the consonant *n*'s functioning in the arresting position in the first phrase and in the releasing position in the second. For instance, such phrases as *this star*, *this tar*, *the star*; *this train* and *the strain*, *a pill* and *up hill*; *a tease* and *at ease*, all depend for their meaning upon the proper handling of the consonant movements.

Voiced and Unvoiced Consonants in the Speech of the Deaf. The most obvious distinction between the stops *p* and *b*, *t* and *d*, *k* and *g*, as these consonants are heard in normal speech, is the silence during the closure of *p*, *t*, and *k*, as contrasted with the voicing during the closure of *b*, *d*, and *g* The question is: How is it possible for air to flow through the glottis to produce this voicing while the vocal canal is closed by the articulation. In the case of the unvoiced stops, *p*, *t*, *k*, the articulation stops the vocal canal, the pressure in the mouth rises immediately to the level of the pressure below the glottis, and no sound is produced But in the case of the voiced stops, *b*, *d*, *g*, it is obvious that the pressure in the mouth rises so slowly that a small amount of air flows through the glottis to produce voice during the consonant There is some compensating movement which enlarges the oral cavity during the closure of the voiced stop. The precise nature of this compensating movement is in dispute

In the case of the voiced and unvoiced continuants, *s*, *z*, etc, the orifice of the articulation is controlled so that the pressure in the mouth is always less than the pressure below the glottis for the voiced continuant, and so that the pressure in the mouth is always equal to that below the glottis for the unvoiced continuant.

The vocal cords themselves cannot be the regulating agency for this distinction between voiced and unvoiced consonants because it is quite possible for laryngectomized subjects speaking with an artificial

larynx, in which the air pressures alone can be controlled, to produce all the voiced and unvoiced consonants.

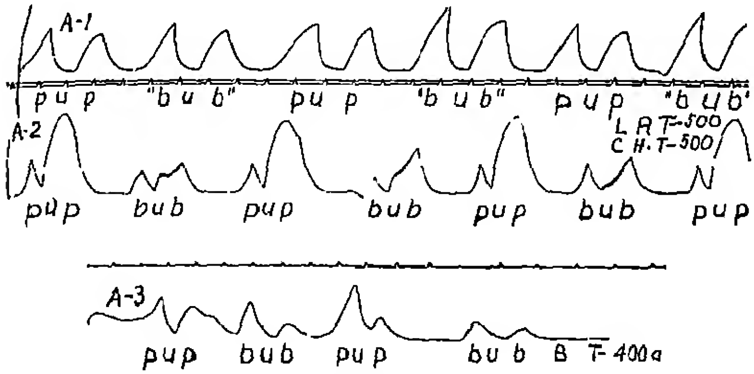

FIGURE 16

RECORDS OF AIR PRESSURE INSIDE THE MOUTH DURING THE ARTICULATION OF VOICED AND UNVOICED CONSONANTS

The tracings were made by means of the small metal tube inserted in the corner of the mouth which records the air pressure during the closure of the consonants

A-1—tracing of the "inside air pressure" of a deaf girl (Group C), age 17 years, while speaking the syllables *pup* and *bub* alternatingly. There is very little difference between the voiced and the unvoiced forms. The pressure rises higher for the "voiced" *b* than for the unvoiced *p* Compare these tracings with *A-2* below it.

A-2—tracing of the "inside air pressure" taken from a normal male adult while speaking the same syllables simultaneously with the subject in *A-1*. Note the difference in the shape of the tracings, also the height. As the lips close for the *p* the pressure rises rapidly to a peak The rise of pressure for the *b* is slower and the rate of rise changes during the closure, as indicated by the inflected form of the curve The voice vibrations are clearly indicated in the *b* tracings There is a distinct difference between the releasing and the arresting consonants

A-3—tracing of the "inside air pressure" taken from a laryngectomized subject speaking the same syllables with an artificial larynx Even though the subject cannot control the glottal opening of the instrument, he is able to make the characteristic distinction in pressures for the voiced and the unvoiced sounds

Time is recorded in 2 sec

Tracings of air pressure within the mouth during the consonant closures for such syllables as *pup*, *bub*, *tut*, and *dud* show that the pressure does not rise as high in the mouth for the voiced consonants

as for the unvoiced consonants. Figure 16 is such a record. The normal tracing, *A-2,* shows the subject repeating *pup* and *bub* alternately. The air pressure for the *p* rises quickly to a maximum and no vocalization is apparent; while the tracing of the *b* shows a more gradual rise and the pressure does not reach the high level of the unvoiced *p*. The "inflected" form of the tracing for both the releasing and the arresting *b* is an indication of some compensatory factor which retards the rise of pressure in the mouth, and the resulting air-flow sounds the vocal cords during the voiced stop. On the same record *A-1,* a deaf subject (female, age 17 years, Group C), was repeating the same syllables simultaneously with the normal subject. It is clear that no such distinctions in the form or height of the tracing appear. The air pressure rises to a greater height during the closure of the *b* than that of *p*. No vocalizations occur. *A-3,* in the same figure, is a similar record taken from a laryngectomized adult who was speaking with an artificial larynx. The same general forms of the curves are apparent as those found in the normal tracing. The difference in air pressures in the mouth during the two types of consonants could have been achieved only by the manipulation of the mouth and chest pressures, since the subject had no direct control over the glottal opening of the artificial larynx.

The deaf subjects, especially those in Groups B and C, all fail to make the distinction between the voiced and unvoiced stop consonants. Frequently they are understood when speaking because of the context, but when they repeat alternately syllables with voiced and unvoiced sounds, such as those mentioned above, it is impossible to distinguish between the sounds as they are heard.

Nasality in the Speech of the Deaf. One of the most constant defects in the speech of the deaf subjects studied in this survey was that of nasality. This defect occurred not only as an excess of nasal resonance during the vowel but also as a leakage of air through the nose during the consonant closure. In its extreme form, the lack of control over the soft palate during the speech process renders the speech of the deaf not unlike "cleft-palate speech." All consonants become nasal and, therefore, continuitives; clear-cut stop consonants become impossible. Records of this air-flow through the nose were taken on a large number of subjects by means of the nasal "olives." The records show that nasality is a common defect in the speech of the deaf, especially among the profoundly deaf group.

Normal subjects learn to control the action of the soft palate in speech by the sound of the voice, the action of the velum in closing the nasal passage becomes automatically coordinated into the entire speech process and no difficulty occurs. The deaf subject has no such cue as the "sound" of his voice and therefore finds it very difficult to control the velum. Once this control is established, however, it is no longer dependent upon the sounds, as is demonstrated by the fact that subjects who become deaf after they have learned to speak do not show any lack of velum control.

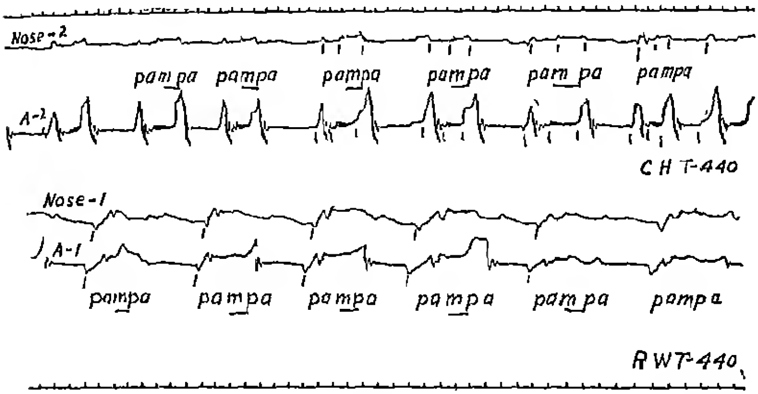

FIGURE 17

KYMOGRAM OF THE WORD "PAMPA" SPOKEN BY A DEAF BOY, AGE 17 YEARS, AND BY A NORMAL MALE ADULT

Tracings from the nose and air pressure from the mouth were taken.

Nose-2—tracing of the air pressure from the nose of the normal subject. There is a brief flow of air immediately preceding the closure of the initial *p* but it is immediately stopped during the closure of this consonant. There is the usual flow of air from the nose for the nasal *m* which ceases at the closure of the abutting *p*.

A-2—tracing of the air pressure inside the mouth taken simultaneously with *Nose-2* above. The tracing shows the usual form for the two *p*'s but no pressure for the *m*.

Nose-1—tracing of the air pressure from the nose of the deaf subject while speaking the word "pampa." The tracing shows unmistakably that there is little control over the soft palate, for the breath flows from the nose for all the sounds in the word. The tracing is almost identical with *A-1* below, as if they were taken from a common pressure chamber.

A-1—tracing of the air pressure inside the mouth taken simultaneously with *Nose-1* above. This tracing shows the same forms for the individual sounds of the word as the nose tracing.

Simultaneous points are checked on the tracings.

Time is recorded in .2 sec.

Figure 17 shows air-pressure tracings taken from the nose and mouth of a normal subject and of a deaf subject while repeating the word *pampa*. The word was chosen because of the abutting consonants *mp*, one of which is a nasal sound and the other is a stop consonant, requiring the opening and closing of the velum. The tracing from the mouth, *A-2*, the normal subject, shows the rise of air pressure during the closure of the *p*'s, while during the closure for the *m* this tracing shows only voice vibrations with zero pressure. Correspondingly, the record from the nose (*Nose-2*) shows no air flowing during the *p*'s, but indicates the flow for the nasal *m*. The slight flow which precedes the initial *p* in pampa is due to the rapid closure of the velum as the lips close. The tracings *A-1* and *Nose-1* were taken from a deaf subject, male, age 17 years, Group C, while repeating the same word. This record was selected because it shows the extreme form of nasality. Both tracings *A-1* and *Nose-1* are strikingly alike, as if they were taken from the same pressure chamber. And, indeed, that is what happened, for there is obviously very little action of the soft palate and the "olives" in the nose and the tube in the mouth were "tapping" a common air chamber. Such extreme lack of velum control is unusual among the group of subjects studied, but many of them show, in a lesser degree, that nasality is a common defect.

Statistical Summary of the Phrase Data. More than two thousand phrase records were measured for all the subjects used in the experiment. Three sets of quantitative data were obtained: (*a*) the time, or duration, of the phrases of different length; (*b*) the relative amount of breath expelled per phrase as measured by the amplitude of the phrasing movement; and (*c*) the rate of air-flow per syllable during the phrase, as measured by the rate of inward movement of the body walls during the phrasing movement.

The summary of these data clearly indicates that there is a decided correlation between the degree of hearing-loss of the deaf subjects and the time required for the repetition of a given phrase and the amount of breath expelled during that phrase. The data of those who have the least amount of hearing-loss coincide most nearly with that of the normal group. The data for those who are profoundly deaf fall farthest away from the normal; while the data of the intermediate group fall between the two extremes. (See Figures 18 and 19.) The amount of residual hearing, therefore, becomes an important factor in the ability to learn to speak by present methods of teaching.

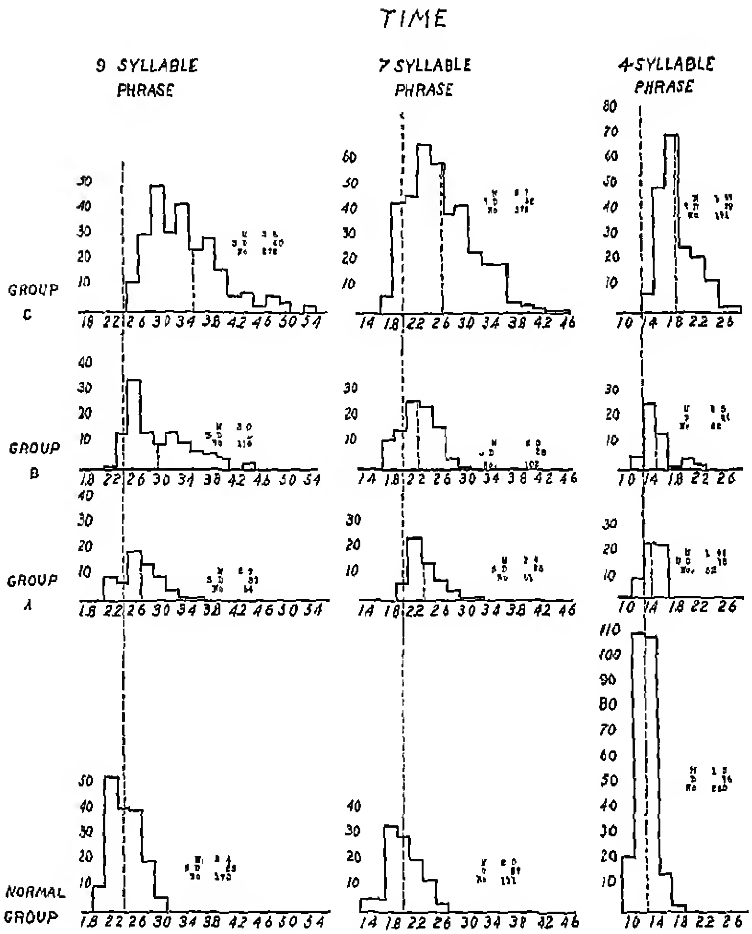

FIGURE 18

DISTRIBUTION CURVES OF THE TIME (IN SECONDS) REQUIRED FOR REPEATING THE NINE-, SEVEN-, AND FOUR-SYLLABLE PHRASES BY THE FOUR GROUPS OF SUBJECTS

The distributions of the normal data are placed at the bottom Groups A, B, and C are arranged above according to the degree of hearing-loss The means of the normal distributions are extended upward through identical points on the base lines of the other distributions The means of all the distributions of the deaf groups fall to the right of, and are therefore higher than, the means of the normal groups The time required for the phrases increases with the increase in hearing-loss

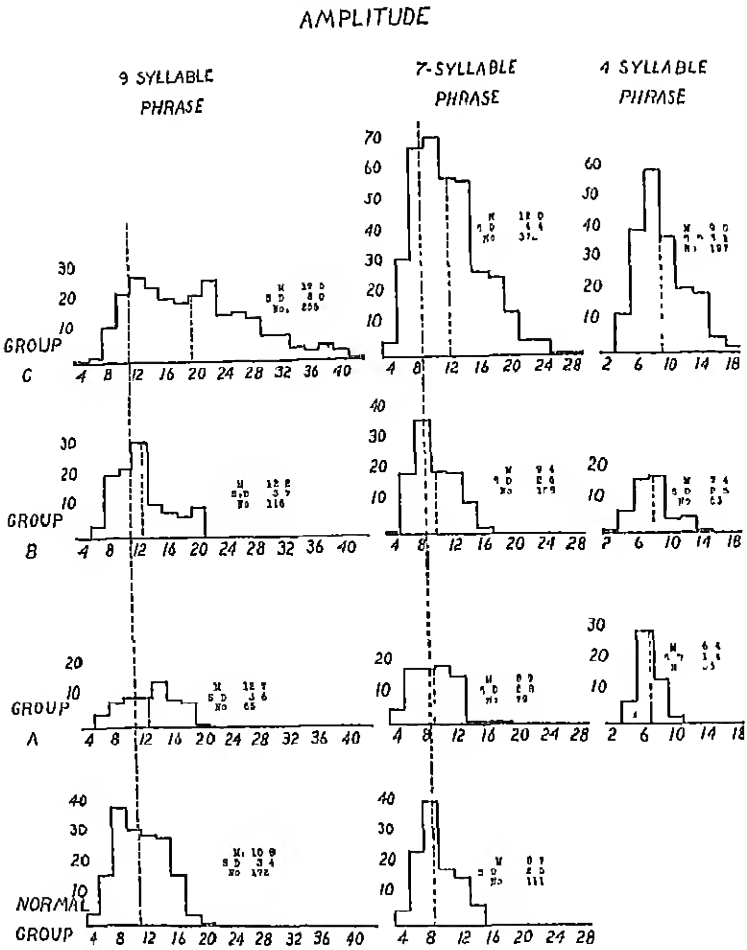

FIGURE 19

DISTRIBUTION CURVES OF THE AMPLITUDES (IN MILLIMETERS) OF THE PHRASING MOVEMENT FOR THE NINE-, SEVEN-, AND FOUR-SYLLABLE PHRASES FOR THE FOUR GROUPS OF SUBJECTS

The distributions of the normal data are placed at the bottom, while the data for the deaf subjects, Groups A, B, and C, are arranged above them according to the degree of deafness The means of the normal group are extended upward through identical points on the base lines of the other distributions. The means of the deaf groups fall to the right of the normal means The amplitude of the phrasing movement increases with an increase in the degree of hearing-loss The measures of amplitude for the four-syllable phrase for the normal group were not available.

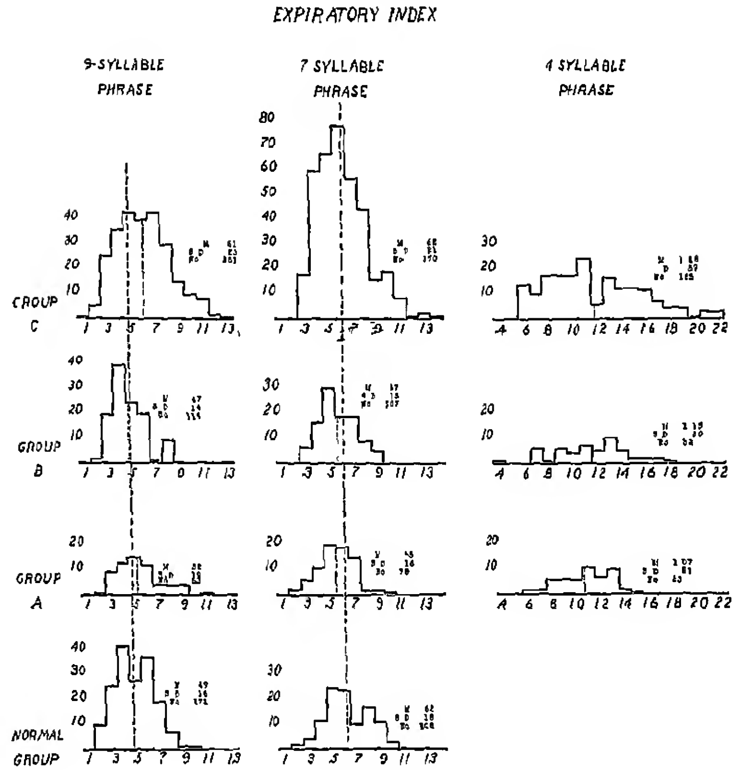

FIGURE 20

DISTRIBUTION CURVES OF THE EXPIRATORY INDEX (RATE OF AIR-FLOW) FOR THE NINE-, SEVEN-, AND FOUR-SYLLABLE PHRASES FOR THE FOUR GROUPS OF SUBJECTS

The distributions of the normal data are placed at the bottom The data for the three deaf groups, A, B, and C, are arranged above according to the degree of deafness The means of the normal group are extended upward through identical points on the base lines of the other distributions. The means of all the distributions very nearly coincide This means that the rate of air-flow per syllable in the phrase was practically the same for all the subjects No data were available for the normal group for the four-syllable phrase

The expiratory index, or rate of breath flow, remains about the same for all four groups The single exception is that of Group C, the profoundly deaf group, for the nine-syllable phrase, in which

TABLE 1

INDIVIDUAL AVERAGES OF TIME, AMPLITUDE, AND EXPIRATORY INDEX FOR NINE-SYLLABLE PHRASE

Sub	Normal group N.	T	A.	E I
C. V	8	2.2	4.9	.24
T B	11	2.6	14.5	64
H C	13	2.8	8.8	34
J D	6	2.3	6.9	33
O D	4	2.6	14.0	.59
P. E.	12	2.5	10.2	.46
F. K	14	2.7	10.6	44
M. K.	11	2.5	12.0	.59
M. LI	10	2.3	7.6	.37
M M.	9	2.4	9.0	42
B O	21	2.2	12.6	64
K O'H.	9	2.6	9.1	39
E O	15	2.1	10.4	.54
M P	13	2.2	11.0	.55
E R.	2	2.4	17.3	.80
J Y	6	2.6	11.3	.48
Total	173			
Mean		2.4	10.8	49
S D		.25	3.4	16
σ_M		02	.26	01

Sub	Group A N	T	A.	E I.
L C	4	3.1	16.0	57
N L	8	2.5	9.6	41
A. M.	10	2.2	15.6	.79
K R	16	2.5	8.8	40
R T	11	3.0	14.5	.53
H. W.	16	2.8	12.0	.44
Total	65			
Mean		2.7	8.9	52
S D		31	3.6	19
σ_M		04	.44	02

Sub	Group B N.	T	A.	E I.
G A.	9	3.9	23.2	62
C. E.	19	2.5	11.2	.50
E E.	14	3.0	13.4	.50
F F.	11	2.6	8.4	.35
E. G	5	3.4	9.6	.31
A Mz	15	3.4	13.1	43
A. P	5	3.6	13.8	43
I R.	31	2.6	9.0	.39
C S	3	3.1	19.3	.71
C. T.	4	3.2	11.8	41
Total	116			
Mean		3.0	12.2	45
S D		.50	3.7	.13
σ_M		05	35	01

Sub	Group C N.	T	A.	E I
S. B	8	3.7	23.2	.70
E Bl	3	4.4	29.0	.73
L Bl.	2	3.5	10.5	.34
G B	2	5.2	22.0	.22
F B	15	3.1	15.6	56
M C.	7	3.3	13.3	44
D Ct	20	2.8	15.7	61
D Cv	5	3.8	12.4	60
S C	8	2.8	13.1	.52
H C.	14	3.1	25.0	86
R C.	6	4.2	26.8	.88
P C	8	3.7	24.4	74
J C	10	3.2	26.2	.87
R DH.	3	4.4	28.0	72
E D.*	3	3.4	21.0	64
H F*	7	2.8	7.8	.32
A. G	14	3.4	22.0	.71
D G.	5	3.0	10.4	.38
S G	18	3.1	9.5	.35
S H*	22	3.0	12.1	43
A. L	4	4.7	24.0	.57
R L	12	3.1	16.9	61
H McD	1	3.8	15.0	33
J McC.	6	3.8	15.7	.57
F McL	4	4.1	11.8	.33
M O'B	2	4.6	20.5	.50
A O	9	3.1	25.8	.96
B P	7	3.9	13.0	38
Bt P	2	4.0	30.0	82
W P	3	5.3	35.0	.74
F R.	1	5.0	18.0	.29
G R.	12	4.0	22.1	62
C. R	11	3.3	22.2	75
P R.	5	4.0	18.8	52
J R.	15	3.5	11.8	.38
S S	3	3.5	19.0	61
O Wh	1	5.4	38.0	78
Total	278			
Mean		3.5	19.5	61
S D		60	8.0	.23
σ_M		.04	.5	01

TABLE 2

INDIVIDUAL AVERAGES OF TIME, AMPLITUDE, AND EXPIRATORY INDEX FOR SEVEN-SYLLABLE PHRASE

Sub	Normal group N	T	A.	E I
H C	24	2.2	7.2	49
J D	7	1.8	6.8	53
O D	8	2.0	7.0	.50
P E	36	1.9	10.3	79
A G	7	1.6	6.1	71
C M	8	2.4	7.8	49
E R	13	1.9	8.4	64
W F	8	2.2	12.0	.78
Total	111			
Mean		2.0	8.7	.62
S D		.27	2.5	18
σ_M		03	.24	018

Sub	Group A N	T	A.	E I.
L C	2	2.7	12.0	62
M. F	5	2.8	8.2	42
M L	10	2.1	9.4	63
A M	18	1.8	6.5	.51
H R	5	2.3	11.6	71
R S.	5	2.7	12.0	64
R T	9	2.3	9.9	62
J T	6	2.4	5.2	32
H W.	20	2.2	8.5	.54
Total	80			
Mean		2.4	8.9	65
S D		.25	2.8	155
σ_M		032	33	018

Sub	Group B N	T	A.	E I
C E	23	2.2	6.9	44
E G	6	2.4	6.6	41
F H	9	1.9	6.1	49
A Mz.	22	2.6	12.3	62
A P	3	2.1	6.7	45
I R	21	2.0	8.5	61
C S	10	2.1	9.1	62
C T	8	2.3	9.8	62
Total	102			
Mean		2.3	9.4	.57
S D		.28	2.6	15
σ_M		027	.25	015

Sub	Group C N.	T	A.	E I.
S B.	13	2.3	11.8	76
E Bl	3	2.4	10.0	61
L Bl	20	2.8	9.3	47
F B	3	4.3	17.7	59
G B	18	2.1	8.0	.57
M C.	7	2.6	8.6	48
D Cv	7	3.0	13.0	.54
S C	7	2.8	14.2	71
H C	9	2.5	16.4	92
P C	8	2.6	14.5	80
J C	15	2.5	14.0	.84
R DH	20	3.2	23.7	60
E D*	2	2.9	20.0	1.01
H F*	6	2.1	4.5	36
A G	7	2.1	12.5	70
D G	34	2.3	7.0	44
S G	11	2.1	7.6	.51
S H*	15	2.3	7.7	42
E K	8	3.1	8.0	.37
R L	16	2.3	11.6	71
H McD	7	3.4	11.7	.51
J McC	14	2.8	14.5	.74
F McL.	17	3.4	10.1	42
A O	12	2.5	18.9	1.16
B P	25	2.6	9.2	.52
W P	19	3.8	22.9	86
G R	13	2.9	15.1	.70
P R	6	3.1	12.5	.58
J R.	14	2.4	7.2	43
S S	4	2.5	13.8	80
O Wh	5	3.1	12.8	.59
R W	13	3.0	14.6	70
Total	378			
Mean		2.67	12.0	62
S D		52	4.4	.21
σ_M		027	.226	011

*Subjects who became deaf after they had learned to speak

TABLE 3

INDIVIDUAL AVERAGES OF TIME, AMPLITUDE, AND EXPIRATORY INDEX FOR FIVE-SYLLABLE PHRASE

Sub	Normal group N.	T	A	E I	Sub	Group A N	T	A	E I.	Sub	Group B N	T	A.	E I	Sub	Group C N	T	A.	E I
T B	5	1.7	13.7	1.60	L C	3	1.4	7.0	80	I R	4	1.7	6.0	75	D Ct	17	1.8	6.6	74
A G	8	1.4	2.6	37	M F	13	1.9	7.0	50	F T	8	2.1	8.0	84	H C	6	1.6	17.2	1.75
M K	13	1.5	5.0	72	K R	4	1.7	5.8	65						P C	8	2.4	7.1	57
C M	13	1.6	7.8	1.10	J T	7	2.1	7.3	69						A G	5	2.1	9.6	90
B O	12	1.4	9.1	1.30											B P	4	2.0	9.8	98
E R	2	1.6	7.0	64											P R	2	2.3	9.0	.79
															R W	10	2.3	7.4	62
Total	53					37					12					53			
Mean		1.6	7.6	.97			1.9	6.2	.57			2.0	7.0	80			2.2	9.2	.77
S D		11	3.3	40			22	1.5	.22			51		43			33	3.6	18
σ_M		014	44	054			04	.35	042			15		125			043	49	023

TABLE 4

INDIVIDUAL AVERAGES OF TIME, AMPLITUDE, AND EXPIRATORY INDEX FOR FOUR-SYLLABLE PHRASE

Sub	Normal group N	T	A	E I	Sub	Group A N	T	A	E I	Sub	Group B N	T	A	E I	Sub.	Group C N	T	A	E I
B C	84	1 3	—	—	L C	5	1 4	7 8	1 70	E E	6	2 1	10 7	1 31	S B	22	1 7	7 9	1 14
J H	84	1.2	—	—	M L	10	1 4	7 1	1.28	F H	12	1 3	4 5	80	L Bl	10	2 1	7 5	91
E H	42	1 2	—	—	R S	10	1 5	5 5	95	A Mz	24	1 4	7 1	1 26	G B	5	2 2	7 8	1 15
C Y	42	1 4	—	—	R T	10	1 3	5 1	1 05	A P	6	1 3	6 3	1 22	D Cv.	6	1 8	14 0	2 00
					J T	4	1 6	7 0	1 16	C T	5	1 5	7 4	1.24	R C	2	2 8	22 0	1 95
					H W.	13	1 5	5 6	94						R DH	3	2 1	10 0	1 20
															H F*	22	1 6	4 4	67
															A G	22	2 1	8 4	1.26
															D G	9	1 8	6 8	95
															S G	10	1 9	4 8	90
															R L	11	1 7	8 7	1 43
															F McL	6	2 3	6 7	71
															B P	24	1 8	8 0	1 21
															W P	10	2 2	11 9	1 47
															G R	4	1 8	11 3	1.56
															C R	1	2.2	14 0	1 60
															P R	8	1 6	3 5	.51
															J R	15	1 7	6 3	1 03
															O Wh	16	2 0	12 3	1 55
															R W	6	1 8	6.5	94
Total	252					52					53					212			
Mean		1 3					1 4	6 4	1 07			1 5	7 4	1 15			1 9	9 0	1 18
S D		16					15	1 4	.21			.24	2 5	30			.29	3 1	39
σ_M		011					021	.19	029			033	34	042			067	.218	029

*Subject who became deaf after he had learned to speak

the rate of air-flow per syllable is somewhat larger. In general, this indicates that if the normal subjects spoke as slowly as the deaf subjects do they would use approximately as much breath as do the latter Thus, increasing the rate in speaking becomes very important for breath conservation in the speech of the deaf.

Tables 1, 2, 3, and 4 give the individual averages of the time, amplitude, and the expiratory index for the four groups of subjects for each of the four phrases used The total averages with the number of phrases measured for each group are presented below each table. These same data are presented graphically in the distribution curves in Figures 18, 19, and 20 In these distribution curves the data for all four groups of subjects used are plotted on the same base line, each phrase length placed one above the other, so that the means of the normal group can be extended through identical points in the curves above them The displacement of the means of the deaf groups to the right of the means of the normal group in Figures 18 and 19 indicates the degree of deviations from the normal. Also, the progressive increase in displacement of the means of the deaf groups with the increase in hearing-loss is clearly evident. In

TABLE 5

SHOWING THE RELIABILITIES OF THE DIFFERENCES IN THE MEAN TIME AND AMPLITUDE BETWEEN THE NORMAL AND DEAF GROUPS

	Normal M	Normal SD	Group A M	Group A SD	Group B M	Group B SD	Group C M	Group C SD
			Nine-syllable phrase					
Time in secs.	2 4	25	2 7	31	3 0	50	3 5	60
$\frac{\text{Diff}}{\sigma_{diff}}$			6 7		12 0		27 0	
Amplitude in mm.	10 8	3 4	12 7	3 6	12 2	3 7	19 5	8 0
$\frac{\text{Diff}}{\sigma_{diff}}$			3.7		3 2		15.5	
			Seven-syllable phrase					
Time in secs	2 0	27	2 4	25	2 3	28	2.7	52
$\frac{\text{Diff}}{\sigma_{diff}}$			9.1		3 3		16 8	
Amplitude in mm.	8 7	2 5	8.9	2 8	9 4	2 6	12 0	4 4
$\frac{\text{Diff}}{\sigma_{diff}}$			49		2 0		9 9	

Figure 20, the expiratory index data, the normal means practically coincide with the means of the deaf groups with the exception of the nine-syllable-phrase data for Group C, the very deaf group. The reliabilities of the differences between the means of the several groups are presented in Table 5

Discussion of Results

The results of this study show very clearly that the speech of the deaf subjects presents such wide variabilities in all the quantitative aspects studied that it becomes impossible to formulate a "standard deaf speech." Even if it were possible to do so, the value of such a standard would be nil since it is the purpose of any progressive oral program to develop normal speech and language in the deaf. Therefore, the speech of normal people is the only legitimate standard with which it is feasible to compare the speech of the deaf.

The quantitative data obtained from the normal group of hearing subjects may be accepted as a standard or "norm" since the distributions fall within a very narrow range, and the amount of data obtained and the number of subjects used are sufficiently large to insure a fair degree of reliability A comparison of the data obtained from the deaf and the normal subjects, therefore, becomes highly significant as a measure of the speech of the deaf.

The degree of abnormality found in the speech of the three subdivisions of the deaf subjects is highly correlated with the degree of deafness These abnormalities may be summarized as follows. (*a*) extremely slow and labored speech, usually accompanied by high chest pressure and uttered with an excess amount of breath, (*b*) prolonged vowels with consequent distortion, (*c*) abnormalities of rhythm, (*d*) excessive nasality of both vowels and consonants; and (*e*) improper function of consonants with the consequent addition of extra syllables at points between abutting consonants.

All of these defects can be classified as incoordinations of the speech muscles That is, they are deviations from the normal speech coordinations rather than specific inaccuracies of speech sounds It is true that inaccuracies of sounds result from the incoordinations of the motor mechanism, but such inaccuracies are effects rather than causes. If the normal speech coordinations were present it is obvious that a large number of the acoustic abnormalities would not appear. Of course, the deaf person can hardly hope to achieve a normal

voice quality or to speak with the normal pitch changes and inflections of voice which are common to hearing people. The absence of the sense of hearing will naturally preclude the control of those acoustic qualities which are dependent upon hearing But the chest-abdominal coordinations involved in the normal phrasing movement, the proper execution of the syllable movement, the proper functions of the consonant in syllables, and the normal speech rhythms are not dependent upon hearing They are similar to other types of skilled movements in that they may be controlled by cues from the movements themselves (kinaesthesis) We have seen how those subjects who lost their hearing after they had learned to speak continue to use the normal speech coordinations although they never hear the sounds which these coordinations produce Indeed, those who are "congenitally" deaf learn a certain type of speech coordination and use it in spite of the fact that they never hear the sounds It seems reasonable, therefore, to assume that if the congenitally deaf person can be taught to speak with a certain type of speech coordination he can be taught the normal, or correct, type.

The correlation between the degree of hearing-loss and the degree of speech abnormality of the deaf is a clear indication that residual hearing is an important factor in the speech development of the deaf. This is not proof, however, that the profoundly deaf child cannot learn the normal speech coordinations; it merely suggests that the problem is more difficult. It suggests also that the methods of training which are adequate for those who have a usable amount of residual hearing are not so efficient in teaching the profoundly deaf.

A recent investigation indicates that residual hearing is a factor even in the prelinguistic vocalizations of young untrained deaf children Miss Sykes (8), in 1933, in a study of the vocalizations of fourteen young deaf children in the entering classes of Clarke School, found that the frequency of vowel sounds was not affected by the degree of deafness But she found a high correlation between the frequency of syllables containing consonants combined with vowels and the degree of hearing-loss. The profoundly deaf child of four or five years used very few consonants combined with vowels in his babbling, while the frequency of such combinations increased with the increase in residual hearing in the group. The findings of Miss Sykes and the results of the present study are evidence that the profoundly deaf child, from the very beginning, presents a different

pedagogical problem than do those who have even a small amount of residual hearing.

The practical implication is that the method of speech training which has been used produces relatively normal speech in those subjects who have sufficient residual hearing to help them, but that such training has been inadequate for the profoundly deaf child since it fails to produce the normal speech coordinations Children who have residual hearing can be taught to speak by means of efficient, modern hearing-aids. Profoundly deaf children are denied this advantage, yet they are to be taught to speak well in spite of this handicap. More efficient methods of speech training are being developed for this group, methods based on a fundamental knowledge of the normal speech coordinations. Experienced teachers, therefore, are to gain a wider knowledge of the developments of experimental phonetics and to use ability and ingenuity in applying this knowledge to their teaching Apparatus which gives visual cues has been developed which can be used in the correction of individual cases of nasality, bad handling of the velum, of inefficient voicing of consonants A stroboscope which gives visual cues for the correction of pitch and inflection of the voice is now past the experimental stage and will be useful in producing voice control in the profoundly deaf Child psychology, especially the phase which deals with the early speech development of normal children, should have much to offer to those who are interested in the problems of the deaf

Summary

The kymographic method was used to study the speech coordinations of sixty-two deaf subjects and twenty-five normal hearing subjects for comparative purposes. All the subjects were required to repeat the same speech materials: phrases of 9, 7, 5, and 4 syllables in length; syllables containing voiced and unvoiced consonants, and words containing nasal and stop consonants. The phrases were measured for the time required for the repetition of a given phrase; amplitude of the phrasing movement, which gave a measure of the relative amount of breath expelled per phrase, and the rate of breath flow per syllable in the phrase. The speech of the deaf subjects shows the following abnormalities when compared with that of the normal group (*a*) extremely slow and labored speech, usually accompanied by high chest pressure with the expenditure of excess

amounts of breath per phrase; (*b*) prolonged vowels with the consequent distortion of these sounds, (*c*) abnormalities of rhythm; (*d*) excessive nasality of both the vowels and consonants; and (*e*) improper function of consonants with the consequent addition of extra syllables between abutting consonants. There is a high positive correlation between the degree of abnormality and the degree of hearing-loss Subjects who became deaf after having learned to speak normally still retain normal speech coordinations. This is taken to indicate that the speech movements are not dependent for their control upon the sounds produced by them The conclusion is that the methods of speech training which have been used are not adequate for the development of normal speech coordinations in the profoundly deaf. A clearer knowledge of normal speech coordinations is to be useful to teachers who are interested in training the profoundly deaf child to speak.

REFERENCES

1. BOUMAN, H D Action current studies of speech movements (*Proc Int Cong. Phonetic Sciences,* Amsterdam, 1932) *Ex d Arch néerl d phonet. expér*, 1933, 8-9, 109-110

2 HUDGINS, C. V, & STETSON, R H A unit for kymograph recording *Science,* 1932, 76, 59-60.

3 MARTIN, —, & HARTWELL, —. Respiratory functions of the intercostal muscles *J. Physiol.,* 1879, 2, 24.

4. ROUSSELOT, — Principes de phonétique expérimentale (2 vols) (New ed.) Paris Didier, 1924 Pp. 1252

5 STETSON, R H. Motor phonetics *Arch néerl. d. phonet expér*, 1928, 3, 1-216.

6. ———. Breathing movements in speech. (*Proc. Int Cong Phonetic Sciences,* Amsterdam, 1932) *Ex. d. Arch. néerl. d. phonet exper*, 1933, 8-9, 108-109

7. STETSON, R. H, & HUDGINS, C. V Functions of the breathing movements in the mechanism of speech *Arch néerl d phonet. expér*, 1930, 5, 1-30.

8. SYKES, J L A study of the spontaneous vocalizations of fourteen deaf children Unpublished thesis, Dept of Educ., Smith Coll, 1933 Pp 65

9 Unpublished records, phonetic files, Oberlin Phonetic Laboratory, Oberlin College

Clarke School for the Deaf
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UNE ÉTUDE COMPARATIVE DES COORDINATIONS DE LA PAROLE CHEZ LES ENFANTS SOURDS ET LES ENFANTS NORMAUX

(Résumé)

On a employé la méthode kymographique pour étudier les coordinations de la parole de 62 sujets sourds et de 25 sujets d'ouïe normale dans le but de les comparer On a fait répéter les mêmes paroles à tous les sujets· des phrases de 9, de 7, de 5, et de 4 syllabes en longueur, des syllabes contenant des consonnes sonores et sourdes, et des mots contenant des consonnes nasales et explosives On a mesuré les phrases pour le temps nécessaire pour la répétition d'une phrase donnée, pour l'amplitude du mouvement des phrases, laquelle a donné une mesure de la quantité relative de l'haleine expulsée à chaque phrase, et pour la vitesse de la respiration pour chaque syllabe dans la phrase La parole des sujets sourds montre les anormalites suivantes quand on la compare à celle du groupe normal (*a*) une parole extrêmement lente et pénible, accompagnée ordinairement d'une haute pression de la poitrine avec l'emploi de quantités excessives d'haleine pour chaque phrase, (*b*) des voyelles prolongés avec la distortion subséquente de ces sons, (*c*) des anormalités du rhythme, (*d*) une nasalité excessive des voyelles et des consonnes, et (*e*) une fonction incorrecte des consonnes avec l'addition subséquente de syllabes supplémentaires entre les consonnes proches Il y a une haute corrélation positive entre le degré de l'anormalité et le degré de la perte de l'ouïe Les sujets qui sont devenus sourds après avoir appris à parler normalement retiennent encore les coordinations normales de la parole On croit que cela indique que les mouvements de la parole ne dépendent pas pour leur gouvernement des sons qu'ils produisent La conclusion est que les méthodes de l'entraînement de la parole employées jusqu'ici ne suffisent pas pour le développement des coordinations normales de la parole chez les très sourds Une connaissance plus claire des coordinations normales de la parole doit être utile aux maîtres qui s'occupent d'entraîner l'enfant très sourd pour la parole.

Hudgins

EINE VERGLEICHENDE UNTERSUCHUNG DER SPRACHKOORDINATIONEN TAUBER UND NORMALER KINDER

(Referat)

Die kymographische Methode wurde ankewandt zur Untersuchung der Sprachkoordinationen von 62 tauben und 25 normalhorenden Versuchspersonen zum Zwecke einer Vergleichung Alle Versuchspersonen wurden aufgefordert dasselbe Sprachmaterial zu wiederholen Ausdrucke von 9, 7, 5 und 4 Silben Lange, Silben, die stimmhafte und stimmlose Konsannanten, und Worter, die Nasen- und Verschlusslaut enthielten Die Ausdrucke wurden gemessen nach der fur die Wiederholung eines gegebenen Ausdrucks gebrauchten Zeit, nach Fulle der ausdruckenden Bewegung, die als Mass fur den relativen Umfang der pro Ausdruck ausgestossenen Atmung galt, nach dem Grad des Atmungsflusses (breath flow) pro Silbe im Ausdruck. Die Sprache der tauben Versuchspersonen weist im Vergleich mit derjenigen der Normalgruppe die folgenden Abnormalitaten auf. (*a*) ausserordentlich

langsame und gezwungene Sprache, gewohnlich von hohem Brustdruck mit Ausgabe ubermassiger Luftmenge pro Ausdruck begleitet; (*b*) verlangerte Vokale mit der damit verbundenen Verbildung dieser Laute, (*c*) Abnormalitaten des Rhythmus; (*d*) ubermassige Nasenbildung der Vokale sowohl wie der Konsonnanten; und (*e*) unpassende Funktion der Konsonnanten mit dem damit verbundenen Hinzufugen von Extrasilben zwischen angrenzenden Konsonnanten Es besteht eine hohe positive Korrelation zwischen dem Grad der Abnormalitat und dem Grad Gehorsverlustes Versuchspersonen, die Taub wurden, nachdem sie normal zu sprechen gelernt hatten, bewahren noch normale Sprachkoordinationen. Dies gilt als Zeichen dafur, dass die Beherrschung der Sprachbewegungen nicht von den durch sie hervorgerufenen Tonen abhangt Die Schlussfolgerung lautet, dass die Methoden des Sprechtrainings, die bisher angewandt wurden, fur die Entwicklung normaler Sprachkoordinationen bei den Starktauben nicht angemessen sind. Eine klarere Erkenntnis der normalen Sprachkoordinationen wird Lehrern, die sich fur das Sprachtraining stark tauber Kinder interessieren, behilflich sein

HUDGINS

WRITTEN TESTS FOR THE CLINIC*

From Danvers State Hospital, Hathorne, Massachusetts

GRACE H KENT

I INTRODUCTION

The Kent-Shakow battery of written tests (4) was formulated in 1925, primarily for the purpose of having a written clinical test which could be used without a time limit The preliminary standardization was done in the schools of Leicester, Massachusetts. The battery then consisted of nine independent units, four of which were later discarded. The following year the five survivors were revised and introduced into the state training schools, with the addition of two other tests which had been standardized without a time limit. Holley Sentence Vocabulary (2), and Trabue Sentence Completion as modified and standardized at the Judge Baker Foundation (1, p. 42) The seven-unit battery thus made up came to publication in 1928, in a very crude state Having no expectation of being able to carry the development any further, the writer thought best to offer the test as it was, with recommendations for revision

The next year this battery was introduced into Danvers State Hospital, and the work of this institution incidentally afforded limited opportunity for group test standardization in a few public schools of Lynn The battery was then thoroughly revised, according to the plan already outlined. The Holley Sentence Vocabulary and the Modified Trabue tests were dropped, on the ground that they required too much time as compared with the other units Woodworth-Wells Hard Directions (8) was adopted in place of the former, and an easier sentence completion test was substituted for the latter

The seven tests, in the revised form, are now distributed by The Stoelting Company, as No. 37031, A to G The units are printed on separate sheets and can be obtained either singly or in sets of seven

Material for standardization has been obtained, at different times,

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(F S INFORMATION [illegible] SHEET A)

1.	America was discovered by	Balboa	Cabot	Columbus	DeSoto
2.	A receiver is a part of a	chair	painting	piano	telephone
3.	Thunder usually comes with	hail	sunshine	lightning	snow
4.	Cheese comes from	milk	nuts	vegetables	eggs
5.	A radiator is a part of a	shirt	desk	roof	automobile
6.	Thanksgiving comes in	April	February	November	December
7.	The number of inches in a foot is	9	12	24	100
8.	Bears live in	dens	[illegible]	houses	[illegible]
9.	The sun rises in the	north	south	west	east
10.	Leather is obtained from	birds	animals	fishes	trees
11.	Chicago is in	Illinois	California	Ohio	Vermont
12.	A swan is like a	pigeon	pheasant	goose	quail
13.	Paris is a city in	Germany	France	Italy	Russia
14.	A wolf is a kind of a	rat	cow	lynx	dog
15.	The iris is a part of the	foot	eye	hand	nose
16.	Jerusalem is in	Austria	India	[illegible]	Palestine
17.	Copperhead is a kind of	bird	coin	snake	turtle
18.	Bricks are made of	clay	stone	fur	wood
19.	Palmerism? is connected with	baseball	shelling?	farming	glasswork
20.	Pasteur is the name of a	merchant	musician	priest	scientist
21.	Gunpowder was invented by	Americans	Europeans	Chinese	Indians
22.	Chess is played on a	court	board	gridiron	links
23.	"The Merchant of Venice" was written by	Shakespeare	Scott	Spenser	Schiller
24.	When it is summer here it is winter in	China	Turkey	Australia	Siberia
25.	The law of gravitation was discovered by	Aristotle	Newton	Copernicus	Bacon

(K S [illegible] SHEET B)

1.	Warm means most like	bake	hot	cake	snow
2.	Afraid means most like	courage	defiant	[illegible]	fearful
3.	Sickness means most like	doctor	health	illness	kindness
4.	Begin means most like	commence	detail	erase	stop
5.	Sleep means most like	awake	bed	hill	slumber
6.	Old means most like	beard	gray	ancient	youth
7.	Often means most like	silent	frequent	never	times
8.	Polite means most like	courteous	[illegible]	gentleman	sulky
9.	Wisdom means most like	aged	knowledge	ignorance	kingdom
10.	Alert means most like	desert	drowsy	spotlight	keen
11.	Frank means most like	candid	crafty	[illegible]	[illegible]
12.	Sly means most like	idle	spy	stealthy	straight
13.	[illegible] means most like	[illegible]	[illegible]	[illegible]	unknown
14.	[illegible] means most like	decline	harmed	[illegible]	rest
15.	[illegible] means most like	content	strength	peace	tender
16.	Help means most like	hinder	house	[illegible]	assist
17.	Pretty means most like	face	ugly	handsome	lady
18.	Sharp means most like	edged	cut	dull	razor
19.	[illegible] means most like	[illegible]	[illegible]	stead	fall
20.	Failure means most like	attempt	[illegible]	success	defeat
21.	Gentle means most like	dental	rough	mild	night
22.	Broad means most like	short	narrow	heavy	wide
23.	[illegible] means most like	truthful	deaf	[illegible]	true
24.	[illegible] means most like	daily	[illegible]	[illegible]	[illegible]
25.	[illegible] means most like	[illegible]	[illegible]	[illegible]	skilled
26.	Command means most like	order	officer	commanded	obey

(K S ESSENTIAL PROPERTY, [illegible] SHEET C)

1.	A river always has	boats	fishes	[illegible]	water
2.	A cat always has	ball	fur	kittens	ribbon
3.	A house always has	roof	fireplace	paint	porch
4.	A sled always has	bells	horses	runners	ropes
5.	A dog always has	kennel	master	[illegible]	nose
6.	A tree always has	leaves	roots	fruit	nuts
7.	A kitchen always has	cupboard	mirror	table	floor
8.	An auto always has	cushions	speedometer	wheels	wind [illegible]
9.	A library always has	books	chairs	magazines	tables
10.	A shoe always has	buttons	sole	laces	lining
11.	A fire always has	coal	wood	heat	paper
12.	A snake always has	[illegible]	poison	rattles	skin
13.	A hill always has	birds	brooks	height	grass
14.	A box always has	cover	sides	hinges	nails
15.	A school always has	pupils	blackboards	desks	[illegible]
16.	A chimney always has	bricks	opening	ivy	smoke
17.	A door always has	hinges	knocker	lock	top
18.	A garden always has	plants	flowers	vegetables	weeds
19.	A ship always has	sail	engine	stern	anchor
20.	A reservoir always has	fishes	contents	sand	fence
21.	A fish always has	scales	[illegible]	spines	stomach
22.	A rowboat always has	oars	keel	bottom	rudder
23.	Wood always has	knots	grain	pitch	bark
24.	A leopard always has	mate	cubs	prey	spots
25.	A grotto always has	cavity	flowers	pools	darkness
26.	A trunk always has	lock	handles	weight	strap

(K S [illegible] SHEET D)

1	breakfast	dinner	grapefruit	supper
2.	bedroom	kitchen	parlor	stove
3.	geography	reading	school	spelling
4.	camera	flute	piano	violin
5.	cow	dog	sheep	[illegible]
6.	bat	[illegible]	field	[illegible]
7	Lincoln	[illegible]	Washington	Wilson
8	beer	[illegible]	[illegible]	[illegible]
9	bread	candy	meat	[illegible]
10.	boots	shoes	slippers	stockings
11	island	lake	river	sea
12	hop	jump	skip	walk
13.	long	broad	short	tall
14.	mouse	rabbit	rat	worm
15.	book	letter	magazine	newspaper
16.	bricks	concrete	shingles	window
17	cry	shout	whisper	yell
18.	bench	chair	sofa	table
19	bag	basket	bottle	valise
20.	recline	rest	sleep	work
21.	duck	goose	hen	swan
22.	chimney	fire	[illegible]	[illegible]
23.	canary	lark	[illegible]	robin
24.	coal	paper	steel	wood
25.	Boston	Florida	Maine	Ohio
26.	forest	grove	tree	woods

(K S ARITHMETICAL REASONING STOELTING 37031 B)

		ANSWER	VALUE
1	If a car travels 30 miles in an hour, how many miles does it travel in one half hour?	15	1
2	If you buy 4 notebooks at 5 cents each and give the clerk a half-dollar how much change do you get?	30	1
3	If a gallon of gas lasts for 10 miles, how many gallons would be used on a 200-mile trip?	20	2
4	If 8 boys club together and pay 2 dollars for the use of a room, how much should each pay?	25	2
5	A boat has 50 staterooms each having 2 berths If 80 berths are taken, how many berths are left unused?	20	2
6	If a single trip cost $1.50 and a round trip $2.50, how much is saved by taking a round trip ticket instead of two singles?	50	2
7	In a class of 32 members, there are 2 visitors and a teacher If 5 students are absent, how many persons in the room?	30	2
8	A girl had 75 cents. If she bought 6 oranges at 50 cents per dozen how much money did she have left?	50	2
9	If there are 4 sausages to a pound, and you are to feed 4 people who can eat 3 sausages apiece how many pounds would you buy?	3	3
10	If 2 pencils cost 5 cents, how much will 10 pencils cost?	25	3
11	If a man walks 4 miles an hour how long will it take him to walk 7 miles?	1 3/4 / 1 45	3
12	If a boy saves 10 dollars each month how much will he save in 2 years?	240	3
13	A movie theatre is open from 11 in the morning until 11 at night. If each performance lasts 2 hours, how many are given in a day?	6	3
14	If 2 yards of cloth cost 50 cents how much will 5 yards cost?	1 25	3
15	In a 150 page magazine pages 31 to 40 are cut out How many pages remain?	140	4
16	If there are 50 nails to a pound and the empty keg weighs 10 pounds, how many nails in a keg weighing 110 pounds?	5000	4

(K S HARD DIRECTIONS STOELTING 37031 - C)

With your pencil make a dot over any one of these letters
1 F G H I J, and a comma after the longest of these three
2 words boy mother, girl Then, if Christmas comes in March,
3 make a cross right here but if not, pass along to the next
4 question, and tell where the sun rises *east* If you
5 believe that Edison discovered America, cross out what you
just wrote, but if it was some one else put in a number to
6 complete this sentence "A horse has *4* feet" Write yes
7 no matter whether China is in Africa or not *yes*, and
then give a wrong answer to this question How many days
8 are there in the week?" *10* Write any letter except g just
9, 10 after this comma *a* and then write no if 2 times 5 are 10 *no*
Now, if Tuesday comes after Monday make two crosses
11, 12 here X X; but if not, make a circle here or else a square
13 here Be sure to make three crosses between the
14 two names of boys George + + + Henry Notice the
two numbers 3, 5 If iron is heavier than water write
15 the larger number here *5* but if iron is lighter write the
16 smaller number here Show by a cross when the
17 nights are longer in summer? In winter? X Give
the correct answer to this question "Does water run uphill?"
18, 19 *no* and repeat your answer here *no* Do nothing
20 here (5+7=), unless you skipped the preceding
question; but write the first letter of your first name and the
21, 22 last letter of your last name at the ends of this line *E*
0

(K S SENTENCE COMPLETION STOELTING 37031 F)

1. Apples grow *on* trees
2. A squash *is* larger *than* a potato
3. The dog chased the *cat*, and the cat *ran* up a *tree*,
4. Hens lay *eggs*, and we *eat* them
5. Ice *melts* in summer and *water* freezes in winter
6. Stoves *are* made *of* iron, tables are *made* of *wood*, and *windows* are made of glass
7. A broom is *used* for *sweeping* the floor
8. Automobile *tires* are *made* of rubber, filled *with* air
9. Most of us *go* to bed at *night* and get *up* in the *morning*, but people who *work* at night have to *sleep* in the daytime
10. If we *go* downstairs rapidly in the *dark*, we *are* likely to *fall*
11. A cube has *six* sides and eight *corners*
12. It *is* a sultry day *in* July Suddenly the *wind* begins to blow *and* a burst of *thunder* is heard A woman *who* is wheeling a *baby* carriage walks as *fast* as she can so as to get *home* before it begins to *rain*

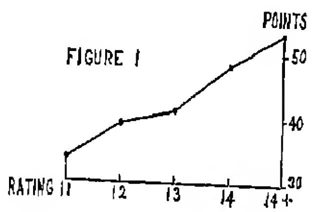

FIGURE 1

SCORES OF KENT-SHAKOW FORM BOARD SERIES (INDUSTRIAL MODEL) CALIBRATED BY THE MEDIAN BATTERY RATINGS OF 187 STATE-HOSPITAL PATIENTS

from the schools of Lynn, Jersey City, Andover, and Danvers.[1] During the first season Sentence Completion was given with a two-minute time limit, and the other six tests were given without time limit. For all records obtained since 1929, each of the tests has been given both with and without a time limit. After having worked two minutes on each of the seven pages, the children were allowed to finish at their leisure with red pencils. Corrections on the first part were permitted, if made in red. Thus each record yields two independent scores, a timed score based upon the responses made with lead pencil and an untimed score which includes all responses on the page. Two sets of norms can now be offered, and it is possible to derive two ratings from each test.

Although group-standardized (as a matter of necessity rather than from choice) the battery is intended primarily for individual examination of clinical subjects. This aim has been kept constantly in mind during the course of standardization. Strict uniformity of diction has been studiously avoided in order to leave the clinical examiner the more free to adapt the presentation to the comprehension of the individual subject. All possible effort has been made to give the group-examined subject the advantages of individual examination. The presentation has been adjusted to the dull or immature members of each group and has been supplemented by any individual instructions that would be permissible in an individual examination. It is on this ground that the cost of standardization is justified. There is no lack of school tests which are presented by a rigidly prescribed formula in order to insure strict uniformity of presentation. The most distinctive feature of this battery is that the objective conditions under which the test is presented are frankly sacrificed in order to secure some approach to uniformity in the subjective conditions under which the test is received.

For all the tests except Hard Directions, comprehension of the requirements is made as easy as possible. Hard Directions is essentially a measure of the subject's ability to follow written instructions.

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[1]For the privilege of working in the schools I am indebted especially to Mary O'Neill of Lynn, Ernest Kent of Jersey City, Henry Sanborn of Andover, and Ivan Smith of Danvers. David Shakow took a generous part in the revision of the tests, as in the original formulation. In the work of collecting and scoring the records I have received assistance from E. Frances Wells, Dorothy McLeod, Lucy Sanborn, Alice Schoenfuss, Mary McLennett and [illegible]

This unit has been introduced into the battery specifically as a test of comprehension in order to cover this particular variable and therefore to make it unnecessary to include difficulty of comprehension as a factor in the rest of the battery For the other six tests, it is understood that the subject is entitled to whatever instructions or repetitions are needed to make the requirements clear to him

II INSTRUCTIONS FOR GROUP PRESENTATION

The test forms are made up in sets, in the following order · (1) Hard Directions, (2) Information, (3) Similarity, (4) Essential Property, (5) Essential Difference, (6) Arithmetical Reasoning, and (7) Sentence Completion Each set has its own serial number, written on each of the seven sheets. It is important that the pages be numbered in advance, as the children cannot be trusted to do it correctly. The seven sheets of a set are held together by a removable paper fastener.

Before the test forms are distributed to the children, the procedure is explained—informally and conversationally—from sample items which have been copied on the blackboard. This explanation is adapted to the comprehension of third-grade pupils.

> "These papers will be placed on your desks wrong side up Write your name on this blank page, and take off the clip Be careful not to do anything else until I tell you When everyone is ready you may turn over the papers, all of you at exactly the same time Be sure to turn the whole pile, like this, just as if they were still clipped together You will then have this page on top (Hard Directions) When I say 'Go,' start reading the page and do just exactly as it tells you Do the best you can until I call time, then stop at once After that you may slip this sheet under the others, this way, and then you will find on top one that begins like this (reading from blackboard)
>
> Maple is a kind of bug cloud metal tree
>
> Which is it? Yes, maple is a kind of tree, so we will draw a line under the word *tree* There is a whole page of sentences like this, and you are to complete each sentence by underlining one of the four words Don't take time to write the word, and don't bother to draw the line very carefully, because you need all your time for the rest of the page See how much of

the page you can cover before I tell you that the time is up . The next page begins like this

Quiet means most like noisy quite still talkative

which is it? Yes, still It sounds most like quite, but it means most like *still,* so we underline *still* On this page be sure to mark the word that means most nearly the same as the first word in the line . Then there is a page beginning

A man always has food glasses head shoes

What is it that he *always* has? Yes, *head* He has food three times a day, sometimes he wears glasses, usually he has shoes, but he always has a head,—he wouldn't be a man without a head In each line on this page, look for the thing that it *always* has, never mind about the things that it usually has; and be sure to mark just one word in each line . The next page begins like this:

apple carrot peach pear

Which of these is most different from the others? *Carrot.* Why is carrot different,—they are all good to eat Yes, carrot is a vegetable and the others are fruits, the carrot grows in the ground while all the others grow on trees Here is another sample

bitter sour sweet white

Which of these is most different? *White.* But why? Bitter and sweet are very different, why is white more different? Yes, because white is a color. Bitter and sweet are very different, but they are both tastes; white is still more different, because it is not a taste at all . The next page has some problems in arithmetic. You may use the margins for figuring, then write the answer on the dotted line. Don't expect to finish, but do the best you can. . . Then the last page has some sentences with words left out, like this. The sky ———— blue What word shall I write in the blank space? Yes, *is* When you come to this page, write one word in each space, the word that makes the best sense I'm going to let you work just two minutes on each of these pages, and then later you may have all the time you need for finishing them. Now I am going to lay the papers on your desks, and remember that they are not to be turned over until I tell you."

It is essential that this explanation be given before the papers are given out, not after or during the distribution. The desks should be clear during the explanation, as otherwise it is difficult to hold the attention of the children to the blackboard

As soon as the slowest child in the room has written his name and removed the clip, possibly with assistance, permission is given to turn the papers over. As they are being turned, examiner repeats the instructions for Hard Directions: "Be sure to do just exactly as this page tells you. Ready . . Go." In response to any question concerning this test no answer is given except: "That's for you to decide," or "We'll be satisfied if you do the best you can."

At the close of the two-minute period the children are instructed to slip this sheet under the others While they are doing this, the essential instructions for the next test are summarized in a sentence, as a reminder of the directions already given from the blackboard. For Information the most important item for reiteration is: "Be sure to underline the word, don't take time to write it." For Essential Property it is advisable to emphasize: "Be sure to mark *just one word* in each line"

After time has been called for the last of the seven tests, the lead pencils are laid aside and the red pencils are given out The children are requested to finish a given page before passing on to another page, but are not required to take the seven tests in any particular order. It is desirable that the effects of fatigue, if appreciable, should be distributed over the seven tests and not concentrated upon one or two. This, however, has been left to chance

Some children prefer to guess when uncertain, while others prefer to omit the item. This matter has been left for the most part to their individual choice, but occasionally a very diffident child has been encouraged to guess.

Examiner and assistants are kept busy answering individual questions, especially in the early part of the period. It is permissible to encourage the children to do their best, to assure them that a perfect score is not expected, and to remind them that the words are to be underlined rather than written. It is important also to prevent cheating and to take down the serial number of a child who deviates from the instructions in such a way as to invalidate any part of his record. When the papers are handed in as completed it is necessary to inspect each page in order to make sure than none are left unfinished.

Short cuts are permissible when the test is presented to school children of the upper grades or to children who are highly practiced in being tested. However important it is to make the requirements

clear to every child in the group, it is not considered necessary to insult subjects of high mentality by presenting the test exactly as it is presented to children in third grade.

III. Clinical Presentation

In an individual examination each unit is presented singly. The procedure is explained from the sample at the head of the page, with as much or as little attention to detail as this particular subject seems to require for a clear understanding of what is to be done. The timing, if done at all, is done as unostentatiously as possible, with no unnecessary formality about starting and stopping. The subject takes his own time for starting, whereupon the examiner quietly starts the stop-watch. At the end of two minutes the subject is requested rather casually to use the red pencil for the rest of the page.

Not every clinical subject can be requested to work under a time limit without destroying the validity of the examination. Some hospital patients, because of pathological retardation, work so slowly that it would be manifestly unfair to evaluate the results in terms of speed. Still other clinical subjects are so nervous and diffident that the timing itself makes the test unfair to them, unless the time record can be taken without their knowledge. For many subjects, therefore, it is advisable to omit the timing and to evaluate the achievement by the untimed norms, as formerly.

Technically, it is easier to present the battery to an individual than to a group, but it is of serious importance to keep the clinical subject at his ease, and this is naturally a more delicate matter for a person examined singly than for a group examined collectively and impersonally.

In order to minimize the subject's consciousness of being observed, the examiner should have at hand some occupation which is obviously not related to the examination. When the subject hands in a completed record the examiner should slip it into a drawer as if it were of no further interest and proceed immediately to the presentation of the next unit. On no account should the record be inspected in full view of the subject.

At the same time, it is a great convenience for the examiner to be able to score each record on the spot, so as to take advantage of the results in deciding what further tests to use. This problem can be

met by having a wide but shallow drawer in the table, after the subject is well started on the next unit, the examiner can then read the completed record under cover, without the knowledge of the subject.

How far an examination should be carried depends upon the reactions of the subject If the first four tests given yield the same rating, the median by the battery is already determined and it is unnecessary to complete it. If the results show the test to be nondiscriminative, if the subject gives unsatisfactory cooperation, or if he shows undue fatiguability, it is useless to continue.

IV. Evaluation of Results

Hard Directions There is practically no limit to the variety of responses which this test elicits It is not to be expected, therefore, that any mechanical scoring system will be subjectively satisfactory The system here offered, with the consent of the authors, is a compromise It is not claimed that the rules for scoring cover all possible responses.

The test includes 22 items, 16 which call for a specified written response, and 6 items (3, 5, 12, 13, 16, 20) which require by inference that nothing be done in a given space. According to the weighting adopted, the perfect score is 38 points Responses are evaluated as follows

1 Two points for each correct response involving a specified mark

2 One point for each correct omission (involving resistance to the suggestion of an incorrect response)

3 Half-credit may be allowed, at the discretion of the examiner, for a partially correct response to a two-point item Examples. (*a*) two crosses, or three dashes, in substitution for three crosses; (*b*) a correct response which is slightly misplaced, (*c*) a possibly correct response which cannot be deciphered with certainty, (*d*) a correct response, accompanied by a very slight superfluous mark.

4 No penalization for incorrect spelling, if the meaning is clear.

5 Corrections are accepted, except for item 20. Inasmuch as this reads "Do nothing here," no credit is given for erasing the response which should not have been written. Full credit for other corrections, if clear.

6 When any considerable part of the page is left blank, no credit is allowed for more than one omission following the last written response, nor for this first omission if it is more than one line removed from the last response.

7. The last sentence (write the first letter of your first name and the last letter of your last name at the ends of this line) includes two items: writing the last letter of the last name as opposed to the two initials, and placing one of these letters at each end of the line, or both letters at each end, as opposed to writing them together at one end only. A subject whose surname begins and ends with the same letter is held responsible for writing the last letter clearly as a lower case letter; for other subjects it may be either a capital or lower case letter. John Doe receives full credit, four points, for writing *J* at the left end of the line and *E* or *e* at the right end, also if he writes *J E* at each end of the line. He receives two points on item 21 for writing the letters *J E* at one end of the line, either the right or the left end. He receives two points on item 22 for writing *J* at one end and *D* at the other, or for writing *J D* at each end. No credit is allowed for writing the two initials at the right end of the line, although this is the most common response, because the subject has overlooked the two specifications which present any difficulty and because any recognition of this response would involve fine splitting of credits.

Information, Similarity, Essential Property, Essential Difference. These four cross-out tests are scored mechanically The items are not weighted. One point is allowed for each correct response, the perfect score being 25 for Information and 26 for each of the others. No deduction is made for responses presumably correct by chance except when a child marks the first or last word of each line consistently for a considerable part of the page. No credit is given for the part of the page thus marked.

Corrections are accepted, if reasonably clear. No credit is given for a line in which two words are marked except when the marking of the correct word is distinctly heavier than the other mark

Cardboard stencils may be made by cutting holes which expose the correct word in each line, holes wide enough to show considerable space below the word. When scoring by stencil it is important to inspect each page carefully for a line in which more than one word has been marked.

Arithmetical Reasoning This test is evaluated by different methods. Independent norms are offered for the following modes of treatment:

1 Sixteen items, with two-minute time limit, unweighted, one point each
2 Sixteen items, without time limit, unweighted, one point each.
3 Sixteen items, without time limit, weighted.
4. First ten items, without time limit, weighted.
5 Last ten items, without time limit, weighted.

The weighting is as follows. One point each for problems 1 and 2, two points each for problems 3, 4, 5, 6, 7, and 8, three points each for problems 9, 10, 11, 12, 13, and 14, four points each for problems 15 and 16

The problems are arranged in order of difficulty, as indicated by a statistical study of the first 1100 records The values are arbitrarily assigned as being easily remembered.

In individual examinations the test is rarely used in full. For a subject of presumably high-grade ability it may be shortened either by using the time limit or by omitting the first six problems For one who is expected to rate below 14 it is customary to use the section including only the first ten problems, but the subject who achieves a perfect score on these problems should be permitted to complete the test, on the chance that his rating may be raised from 14 to 14-plus.

Sentence Completion. Like Hard Directions, this test is highly composite and elicits an indefinite variety of responses Each blank space is counted as an item. Each word correctly supplied receives credit of two points, with no penalization for incorrect spelling when the meaning is clear Full credit may occasionally be allowed for an unusual response, depending upon the context.

One-point credit is allowed for the following (*a*) A word which is grammatically incorrect but otherwise acceptable for full credit (*b*) A two- or three-word response which makes good sense and which is grammatically correct (*c*) A correct response slightly misplaced or not clearly legible

The following list, prepared by Miss Dorothy McLeod and based upon a statistical study of all responses found in 500 records, may serve as a scoring key. Full-credit responses, in italics, are given in order of frequency Half-credit responses are alphabetically ar-

ranged. This list includes all the one-word responses accepted for half-credit, except those which are fully covered in the general rules stated above. Only a few two-word responses are included.

(1) *On*—from, in (2) *Is, grows* (3) *Than, then.* (4) *Cat* (5) *Ran, went, climbed*—chased, jumped, sprang. (6) *Tree*—hill. (7) *Eggs* (8) *Eat, gather, buy*—cook, feed, have, like, sell, take (9) *Melts, thaws*—goes (10) *Water*—always, it, then (11) *Are.* (12) *Of*—from, with (13) *Made* (14) *Wood* (15) *Windows, bottles, tumblers, bulbs tubes, mirrors, eye-glasses*—counters, dishes, glasses, saucers (16) *Made, used*—bought, good, kept, meant, something, straw (17) *Sweeping, cleaning.* (18) *Tires, tubes*—wheels (19) *Made*—always (20) *With.* (21) *Go* (22) *Night*—eight (or any other hour), sunset (23) *Up*—sleep. (24) *Morning*—daytime, night. (25) *Work*—don't play, sleep, stay up, wake. (26) *Sleep*—go, wake, work (27) *Go, run, walk*—come, fall, hurry (28) *Night, dark*—morning, school, winter. (29) *Are* (30) *Fall, trip, stumble*—disturb others, get hurt, slip (31) *Six*—some (32) *Corners*—points (33) *Is, was*—rains. (34) *In*—for, of (35) *Wind*—horn, rain, trees, whistle (36) *Then, and*—as, soon, suddenly, when. (37) *Thunder*—fireworks, noise, rain (38) *Who, that*—which, whom (39) *Baby, baby's*—big, small (40) *Fast, quickly, rapidly*—far, straight (41) *Home, there, in*—away, indoors, safe, shelter (42) *Rain*—lighten, pelter, storm

When given without a time limit, this test may be shortened by omitting the last two sentences. Norms are given separately for the first ten sentences and for the whole page of twelve sentences. The shorter form is convenient for subjects of the lower levels, but is not discriminative above the age of twelve.

V. Standardization and Norms

The number of children included in the norms is 1792 They were in Grades 3 to 8, and their ages ranged from eight to fourteen, nearest birthday. No use has been made, at present writing, of any records obtained from children outside of these age limits The norms without time limit are derived from the 1792 records, but the time-limit norms are based upon only 688 subjects. (These figures are reversed for Sentence Completion, which was given with time limit, but not without, to the first 1100 children)

TABLE 1
MEDIAN SCORES, WITHOUT TIME LIMIT

Age	Number of cases	Hard Directions	Information	Similarity	Essential Property	Essential Difference	Arithmetical Reasoning	Sentence Completion
8	82	13	10	6	11	10	0	28
9	220	19 5	13	8	12	14	2	41
10	291	23	14	10	14	16	3	65 5
11	348	26	16	13	15	18	6	64
12	394	28	18	15	17	19	8	69
13	281	29	18	17	18	19	9	71
14	176	29	19	18	18	20	10	70

TABLE 2
MEDIAN SCORES, WITH TWO-MINUTE TIME LIMIT

Age	Number of cases	Hard Directions	Information	Similarity	Essential Property	Essential Difference	Arithmetical Reasoning	Sentence Completion
8	54	3	4	3	7 5	5 5	0	9
9	75	6	7 5	4	10	9	1	15
10	98	10	12	7	12	13	2	18
11	123	14	14	9	14	16	2	22
12	157	16	16	13	15	18	4	26
13	109	20	17	15	16	18	4	30
14	72	18	16	14	16	17	4	30

TABLE 3

NORMS, WITHOUT TIME LIMIT

Age	Hard Directions	Information	Similarity	Essential Property	Essential Difference	Completion. 10 sentences	Completion 12 sentences
8	10-15	7-10	5- 7	8-10	8-11	16-26	22-34
9	16-20	11-12	8- 9	11-12	12-14	27-37	35-47
10	21-23	13-14	10-11	13-14	15-16	38-46	48-59
11	24-26	15-16	12-13	15-16	17-18	47-50	60-66
12	27-29	17-18	14-16	17-18	19-20	51-53	67-71
13	30-32	19-21	17-20	19-21	21-22		72-76
14	33-35	22-23	21-24	22-24	23-24		77-81
14+	36-38	24-25	25-26	25-26	25-26		

TABLE 4

NORMS, WITH TWO-MINUTE TIME LIMIT

Age	Hard Directions	Information	Similarity	Essential Property	Essential Difference	Sentence Completion
8	2- 4	2- 5	2- 3	4- 7	4- 7	8-12
9	5- 8	6- 9	4- 5	8-10	8-11	13-16
10	9-11	10-12	6- 8	11-12	12-14	17-19
11	12-14	13-14	9-11	13-14	15-16	20-23
12	15-18	15-16	12-14	15-16	17-18	24-28
13	19-21	17-18	15-17	17-18	19-20	29-33
14	22-29	19-21	18-23	19-23	21-23	34-39
14+	30 up	22-25	24-26	24-26	24-26	40 up

The median scores for each test at each age level are given in tabular form, the scores with unlimited time allowance in Table 1, and the two-minute scores in Table 2. The number of cases as given in these tables includes all the children of a given age and is only approximate for any particular test. There was some slight loss of records for each of the test units, especially at the lower age levels For example, a few of the timed records were invalidated because the children wrote words which should have been underlined, and a few of the untimed tests were accidentally left unfinished The number of scores thus lost is negligible, but it would be more serious if it seemed necessary to sacrifice the entire record of every child who lost one of his fourteen scores.

The norms, with such deviations from the actual age-curves as have been adopted, are given in Tables 3, 4, and 5.

TABLE 5
NORMS FOR ARITHMETICAL REASONING

Age	16-items 2 minutes	16 items no time limit 1 point each	16 items no time limit weighted	First 10 items weighted	Last 10 items weighted
9	1	1- 2	1- 4	1- 3	
10	2	3- 4	5- 9	4- 6	2- 5
11	3	5- 6	10-15	7-10	6- 9
12	4	7- 9	16-20	11-14	10-13
13	5-6	10-12	21-25	15-18	14-18
14	7-9	13-14	26-33	19-20	19-24
14+	10 up	15-16	34-40		25-30

Naturally, it would require a much larger number of cases to yield medians that could be accepted unaltered for norms, and it would require also a better distribution of ages If the battery were to be standardized properly for the ages eight to fourteen, the norms should include a fair proportion both of the eight-year children who have not yet reached third grade and of the fourteen-year children who have passed beyond eighth grade. This undertaking offered no opportunity for obtaining well-balanced data at the ends of the scale It has therefore seemed necessary to lower the scores for the eight- and nine-year levels and to raise them for the years thirteen and fourteen The scale is strongest at the twelve-year level, qualitatively as well as numerically For this reason the twelve-year median score has in every instance been accepted unal-

tered for the norms and has been used as a starting-point for whatever alterations have been made

With the exception of Arithmetical Reasoning, which yielded zero scores at each age, the results showed few zero scores or perfect scores. At each age, however, the range of individual variation was very wide. In any given group of children the higher scores were usually achieved by the younger members of the group.

The level designated as fourteen-plus does not represent an age, but merely indicates a score a few points higher than what is accepted as the fourteen-year score

VI. Serviceability of the System

The advantages of a test battery over a composite test have been emphasized by Kuhlmann (5), but in general they have received too little attention.

There are many ways by which some part of a test record may be lost or invalidated, especially when the test is timed The most careful examiner may occasionally make an error in operating a stop-watch, or the watch itself may give out at a critical moment Something so extraneous as the noise of a passing truck may divert the attention of the subject from his task. Even when external conditions are satisfactory, the cooperation of the clinical subject is a variable upon which the validity of the test must necessarily depend One subject is unwilling at first, but forgets his objection to the examination as his interest in the tasks develops, another does well at first, but suddenly decides that he will go no further, and still another gives passable cooperation for parts of the examination while flatly refusing to perform certain particular tasks.

The composite test suffers as a whole when any given element is invalidated, for whatever reason. On the other hand, the battery is weakened very little, if at all, by the loss of some particular unit. Frequently it is possible to substitute some other test for the lost unit so as to preserve the desired number of elements; and even when the examination is brought to a premature close by the refusal of the subject to give further cooperation, it may still be possible to give him a tentative rating by using the median of the ratings which represent satisfactory effort.

The Pintner-Paterson Performance Scale (7), published in 1917, offers a loose collection of tests which can be used in whole or

in part, as desired. One can introduce into this system any additional test which is independently standardized, so as to take full advantage of whatever test materials are at hand. After having adopted this method in 1920, the writer carried it further in 1923—combining language tests with performance tests in order to derive the median rating from a larger number, using in a single system any available test short enough to be included as one element of an examination and urging that composite school tests be published with independent norms for each unit (3).

Not one of the tests thus recommended in 1923 is still used by the writer, but the method has been greatly strengthened by ten years' service. At present writing the findings by language tests and non-language tests are reported separately, and in each of these two groups any unsatisfactory unit is discarded whenever it is possible to find or devise anything similar which is less open to objection. The system is a growing one, and so elastic as to permit indefinite growth.

The seven-unit battery here described constitutes an important part of the system. It is in constant use at Danvers State Hospital, both for hospital patients and for adolescent subjects examined in outpatient clinics. Each of the units is adequately discriminative for the ages nine to fourteen, a range which covers the great majority of the subjects referred for examination, and it is therefore particularly useful in examining an adult subject whose mental level is wholly a matter of conjecture. It affords a satisfactory substitute for the Stanford-Binet scale, which is now rarely used for an adult subject who can read with sufficient fluency to take a written test.

Almost any intelligent and literate person prefers a written to an oral examination, and this holds just as truly for the clinical subject as for the candidate for a university degree. Except at the lower mental levels, an examination by the Stanford-Binet scale is an ordeal which the adult or adolescent subject should be spared if possible.

However, a written test having a time limit cannot be accepted unreservedly in substitution for an oral test which is given without time limit. Even so elaborate a test as the Kuhlmann-Anderson system (6), which is discriminative from six years to maturity and which includes 39 independent units, does not meet the needs of the clinic in examining the subject who is unable or unwilling to work

at his normal maximum speed or the nervous subject who cannot do himself justice while being timed.

The serviceability of the battery is increased to a considerable extent by the time-limit norms which have recently been developed; but the fact that the test can be used without a time limit still remains its most distinctive feature

VII. Battery as a Calibrator

Considerable use has been made of the battery as a calibrator for tests which are standardized inadequately if at all Subjects of various ages are grouped according to their median ratings by the battery as if these ratings represented their actual ages. Within each group of a given mental level as thus determined, the raw scores achieved in some unstandardized test are arranged in order of rank and the median score is taken tentatively as the equivalent of the median score at the corresponding age level. By this method it is possible to obtain a passably smooth curve from a much smaller number of cases than would be required if the subjects were normal children grouped according to age.

The results of one such study are presented graphically in Figure 1 (p. 51). Although the test used as a calibrator is a language test having no time limit, the test calibrated by it in this instance is a mechanical performance test scored by speed. The subjects were state-hospital patients.

The unexpected uniformity of this curve is significant as showing the possibilities of correlation between two tests which are about as different as possible It would not be permissible to accept the findings thus obtained as if they represented actual norms, but the results of such calibration are useful as a check upon whatever crude norms may be available. The routine use of the battery for about 300 patients each year makes it a comparatively simple matter to collect data of this nature for any test which offers fair promise of being worth standardizing for hospital use This has been found a valuable and economical method of preliminary standardization, and it is used regularly as a means of selecting tests which are to be standardized.

VIII. SUMMARY

The Kent-Shakow written battery of seven units, thoroughly revised, has been standardized on a small scale both with and without time limits The time allowance for each unit is two minutes. After the subject has worked two minutes with a lead pencil he is requested to finish the page with a red pencil and is permitted to make corrections in red. It is thus possible to obtain two scores for each unit The median rating may be derived from fourteen independent ratings, or there may be two median ratings, with and without time limits, each based upon seven units.

The battery is discriminative for the ages nine to fourteen, and for many subjects within this range it may be substituted for a Stanford-Binet examination It is a comfortable test for general use in the clinic, being especially serviceable in examination of state-hospital patients who do not respond well to oral questions

The battery is useful also as a calibrator of unstandardized tests. In an institution in which this system is used as a routine measure it is possible to collect—almost as a by-product—material which is valuable for preliminary standardization of new tests

REFERENCES

1. BRONNER, A F., HEALY, W, LOWE, G M., & SHIMBERG, M E A manual of individual mental tests and testing Boston: Little, Brown, 1927. Pp x+287
2. HOLLEY, C. F Mental tests for school use *Bull Bur Educ Res, Univ. Ill.*, 1920, No 4 Pp 6+91
3. KENT, G. H Combination mental test for clinical use *J Appl. Psychol*, 1923, 7, 246-257
4. KENT, G H, & SHAKOW, D. Group tests for clinical studies *J Genet Psychol*, 1928, 35, 595-618
5. KUHLMANN, F A median mental age method of weighting and scaling mental tests *J Appl Psychol*, 1927, 11, 181-198
6. KUHLMANN, F, & ANDERSON, R G. Kuhlmann-Anderson intelligence tests, instruction manual (3rd ed, rev) Minneapolis, Minn Educ Test Bur, 1930
7. PINTNER, R., & PATERSON, D A scale of performance tests New York: Appleton, 1917 Pp x+218
8. WOODWORTH, R S, & WELLS, F L Association tests *Psychol Rev, Monog Suppl*, 1911, 13, No 57 Pp 85

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DES TESTS ÉCRITS POUR LA CLINIQUE

(Résumé)

La batterie écrite de sept parties de Kent-Shakow, très révisée, a été standardisée sur une petite échelle avec et sans limites de temps. Le temps permis pour chaque partie est de deux minutes. Après que le sujet a travaillé pendant deux minutes au crayon, on lui demande de finir la page en employant un crayon rouge et lui permet de faire des corrections en rouge. Il est ainsi possible d'obtenir deux résultats pour chaque partie. On peut dériver le rang médian de quatorze rangs indépendants, ou il peut être deux rangs médians, avec et sans limites de temps, chacun basé sur sept résultats.

La batterie est discriminative pour les âges neuf à quatorze, et pour plusieurs sujets entre ces âges on peut l'employer à la place d'un test Binet-Simon. C'est un bon test pour l'emploi général dans la clinique, étant surtout utile pour l'examen des aliénés qui ne répondent pas bien aux questions orales.

Cette batterie est aussi utile comme méthode d'étalonnage des tests non étalonnés. Dans une institution où l'on emploie ce système comme mesure routinière il est possible de ramasser—presque comme produit de second lieu—de la matière qui est de valeur pour l'étalonnage préliminaire d'un nouveau test.

KENT

SCHRIFTLICHE TESTE FÜR DIE KLINIK

(Referat)

Die Kent-Shakow-Batterie von sieben Einheiten, die gründlich umgearbeitet wurde, ist in einem kleinen Masstab mit und ohne Zeitgrenze normalisiert worden. Die für jede Einheit erlaubte Zeit beträgt zwei Minuten. Nachdem die Versuchsperson mit einem Bleistift gearbeitet hat, wird sie aufgefordert, die Seite mit einem Rotstift fertig zu machen und ihr erlaubt Korrekturen in Rot anbringen. In der Weise wird es möglich zwei Angaben pro Einheit zu erhalten. Die mittlere Beurteilung kann aus 14 unabhängigen Beurteilungen abgeleitet werden, oder es mögen zwei mittlere Beurteilungen mit und ohne Zeitbegrenzung sein, wovon jede auf sieben Einheiten beruht.

Die Batterie lässt Unterscheidungen zu für das Alter von neun bis vierzehn Jahren, und für viele Versuchspersonen innerhalb dieses Umfangs kann sie die Stanford-Binet-Prüfung ersetzen. Es ist ein angenehmer Test für den allgemeinen Gebrauch in der Klinik und ist besonders wertvoll bei der Prüfung von Geisteskranken, die auf mündliche Fragen nicht gut reagieren.

Die Batterie dient auch als Kalibrator nicht normalisierter Teste. In einer Anstalt, in welcher dieses System als gewohnheitsmässige Prüfung gebraucht wird, ist es möglich, fast als Nebenprodukt Material zu sammeln, das für die vorläufige Normalisierung neuer Teste wertvoll ist.

KENT

A COMPARATIVE STUDY OF FINGER-MAZE LEARNING BY BLIND AND SIGHTED SUBJECTS*†[1]

From the Department of Psychology of the Texas State College for Women

Bertha K Duncan

Introduction

The purpose of this study is to compare the ability of blind and sighted subjects in learning a new spatial adjustment in which the tactile cues are the dominant ones. For some time mazes of varying patterns have been used with animals and human beings. Most of the work with human subjects has been with the stylus maze Carr's (4) report of Koch's work indicates that the stylus maze presents a more difficult problem for the blind than for those with normal vision This was confirmed in a later and more comprehensive study by Koch and Ufkess (11)

The blind indubitably possess superiority in their ability to use tactile, auditory, and probably kinaesthetic cues in guidance in certain situations It is, therefore, generally assumed that the acuity of these sense-organs is correspondingly increased Seashore (15) distinguishes between sensitivity and ability to use a sense, i e, between inborn or innate sensory capacity and acquired sensory acuity or skills. Experimental evidence seems to be about equally divided as to the superiority or non-superiority of the tactile sensitivity of the blind The diversity of findings may be attributed to the lack of uniformity in conditions under which the various experiments were conducted In the determination of tactile sensitivity, or tactile discrimination of space, the "two-point threshold" method has largely been used. Important modifying factors here are the kind of aesthesiometer used, the degree of attention given, and the chance suggestions

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received These have been neither adequately controlled nor considered in the conclusions drawn from many of the experiments. Griesbach (6) gives an elaborate account of earlier work along this line, particularly that of Czermak, Gartner, A Stern, and Uhthoff The first three individuals mentioned found the blind to be superior to the sighted in tactile discrimination of space, while Uhthoff found no difference. Griesbach's experiment, however, pointed to the fact that there was a difference, which, though slight, proved disadvantageous to the blind

Experiments by Burnell and Stowell reported by Stratton (16) seemed to show also that the blind were slightly superior. Seashore (15) found that the threshold for the blind was neither lower nor higher than for the sighted, although the latter varied within the group more than the former. This is one of the earlier experiments in which there was an attempt to equate the two groups on the basis of intelligence; yet age as a factor was neglected.

Several other studies show results pertinent to our problem. Stratton and Brown's (16) findings support the earlier experiments of Czermak, Gartner, and Stowell. Carr's (3) experimental work with white rats confirmed the findings of Watson (20), Bogardus and Henke (1), and Vincent (18) that the white rat learns the standard type of maze primarily in tactual and kinaesthetic terms, control being gradually transferred from contact to kinaesthesis, and, when the response is perfected, the function is a kinaesthetic motor-coordination It is probable, in fact it is evidenced by Vincent's work, that visual, auditory, and olfactory cues are used, but for the white rat they seem less effectual than those of contact and kinaesthesis. Perrin (14), in his work on the maze learning of human beings, concludes that their general handling of the situation was not outstandingly different from that of animals as described by Watson. He further states that, as in Watson's work, the cutaneous and kinaesthetic cues were of basic importance And, lastly, for this brief review Knotts and Miles (10), using a high-relief finger maze as was used in this experiment, and also a stylus maze of the same pattern, find that the former type of maze is a less difficult problem for both the blind and sighted subjects. They also find that the stylus maze is more difficult for the sighted than for the blind, while the finger maze is of about equal difficulty for the two groups.

Method

In this study the blind subjects were high-school students from the Texas State School for the Blind located at Austin; their ages ranged from 13 to 25 years Results were obtained for a total of 59 blind subjects, but only 30 were successfully matched in intelligence and scholastic standing with sighted subjects. Later in the discussion it seems feasible to use the entire group of 59 blind when no comparisons are attempted with the sighted group, hence the terms "matched" and "total" blind groups will be used

The visual experience of these individuals varied widely, since admission to the school for the blind is based on the definition of blindness as "inability to progress normally with seeing children in public schools." The inadequacy of this definition is obvious Many totally blind have not been so from birth, most of the subjects were not totally blind. Of the last-named group visual efficiency is represented in varying degrees described as "shadow vision" (ability to distinguish light from dark), described by the oculist as light-perception, ability to distinguish objects in a room, recognition of colors, ability to read headlines of a newspaper, ability to read ordinary print for a short time; and other degrees of visual acuity. Visual experience, however imperfect or limited as to time, seems materially to affect an individual's maze-learning ability since Koch and Ufkess (11) found that those who had had visual experience more nearly approached the sighted in success of response than did the totally blind Table 1 describes the blind subjects and their visual efficiency. They are arranged in descending order of degree of blindness, in some cases the degree is the same.

The sighted subjects were selected from senior high-school students An attempt was made to equate the two groups on the basis of intelligence test scores and chronological age. Table 2 gives the two groups paired according to these two criteria. The findings of Warden (19), Hunter (8), and Tolman (17) indicate that intelligence facilitates success in the maze-learning process, while those of Heron (7) indicate that individual ability and chance are factors of about equal importance in this type of learning Also we must consider intelligence since the same factors causing blindness may have produced a mental deficiency

The sighted subjects were selected from high-school classes in typewriting All students in the school for the blind are required to

TABLE I

THE THIRTY MATCHED BLIND SUBJECTS WITH DEGREE OF BLINDNESS AND DURATION OF SIGHT

Subject	Oculist's report* REV	LEV	Degree of blindness	Duration of sight
6	0	0	total	5 or 6 years
7	0	0	total	18 months
13	LP	0	objects, colors	birth
15	0	LP	total, partial to 12th year	12 years
16	0	LP	reads print some	6 months
17	0	LP	light and darkness, colors	3 years
18	F 6 in	0	light and darkness; tells time	2 years
19	0	F 1 ft	light and darkness, headlines	birth
23	LP	LP	large objects between light and eye	birth
24	LP	LP	light and darkness	7 or 8 years
26	LP	LP	some light	3 months
27	LP	LP	light	1 year
28	LP	LP	large print	2 months
29	LP	LP	light and darkness	1 years
31	LP	LP	objects, colors	7 months
32	LP	LP	light and darkness	16 months
33	LP	LP	objects, colors	birth
34	LP	LP	partial, colors	birth
40	F 1 ft	F 1 ft	light, colors	13 years
42	F 2 ft.	F 2 ft	reads ordinary print some	birth
44	F 2 ft	F 3 ft	reads print (dislocated lens)	birth
46	F 6 ft	F 6 ft	reads print some	birth
47	F 6 ft	F 10 ft.	(double dislocated lens)	birth
51	20/200	10/200	objects, recognizes people	6 years
53	20/200	20/200	large print	birth
54	20/200	20/200	reads print; growing worse	birth
55	20/200	20/200	reads large print	less than 1 year
56	18/50	10/200	(normal until 5 years ago)	11 years
57	20/50	20/70	partial; reads print	birth
59	20/200	20/20	reads headlines; albino	birth

**0* indicates total blindness; *LP* indicates the individual has only the ability to tell light from dark; *F 6 in* indicates the individual can distinguish or count fingers at a distance of 6 inches from the eye The figures are in terms of Snellen's chart, e g, 20/200 indicates the ability to read the 200-line of this chart at a distance of 20 feet; 20/20 is normal vision

study typewriting, beginning in the last year of elementary school It may be said that different amounts of practice in typewriting will make for different rates of speed of symbolic response, and that those subjects of the lower grades will be handicapped since the first-year high-school, blind students, for example, had studied typewriting only

one year, those of the second year two years, etc It is also true, however, that sighted individuals write longhand at different rates of speed, therefore the slower ones are handicapped

The Chapman Group Intelligence Examination without Prepared Blanks (5) was used in this study for both groups, since it is a test administered orally and thus for our purposes presenting fewer difficulties than other group tests All answers were written by means of

TABLE 2

THE BLIND AND SIGHTED SUBJECTS PAIRED ACCORDING TO CHRONOLOGICAL AGE AND INTELLIGENCE TEST SCORES

Blind Subject	Blind CA	Blind Test score	Sighted Subject	Sighted CA	Sighted Test score
6	20	70	1s	19	71
7	16	79	2s	17	80
13	16	49	3s	16	49
15	18	61	4s	18	61
16	17	91	5s	17	86
17	16	56	6s	17	52
18	17	71	7s	17	70
19	16	59	8s	16	58
23	15	54	9s	15	55
24	15	66	10s	17	67
26	17	62	11s	19	59
27	19	73	12s	19	74
28	21	56	13s	17	53
29	16	61	14s	17	62
31	17	48	15s	16	52
32	16	64	16s	16	63
33	16	52	17s	17	52
34	18	63	18s	18	63
40	20	44	19s	20	44
42	18	67	20s	18	66
44	19	64	21s	18	64
46	19	62	22s	18	62
47	19	46	23s	19	51
51	18	58	24s	17	60
53	18	70	25s	18	70
54	18	52	26s	18	52
55	17	45	27s	17	44
56	18	54	28s	18	53
57	17	67	29s	17	68
59	20	62	30s	20	62
Mean	17 6	60 9	Mean	17 5	60 8
Median	17 5	61 5	Median	17	61 5
M D	1 2	7	M D	1 13	7 3
S D	1 5	10 03	S D	1 5	9 7
Q D	1 5	7 3	Q D	5	7 8

the typewriter. The directions for giving and scoring the test were followed exactly except that a bell was tapped to stop the typewriting so that the subjects might hear the reading of the next question. The typing was stopped at the sound of the bell, then all shifted simultaneously to the next position and wrote the number of the next question and then awaited the reading of that question. The experimenter was aided by two monitors in controlling this time factor. That this test is a fairly good measure of relative mental ability is indicated by the fact that test results for a total of 59 sighted subjects gave a mean of 63 and a median of 63, and for 59 blind subjects a mean of 60 and a median of 61 Further evidence is given by the fact that for the blind subjects the coefficient of correlation is $61 \pm .07$ between the results of this test and average ratings of the subjects by five teachers who have taught in the school for the blind

The objection may be raised that the blind are a retarded group from an age-basis point of view, since they often enter school later, hence the sighted subjects will be a mentally deficient group if selected on an age basis alone The pairing of the two groups on the bases of age and intelligence test scores will in a measure obviate this difficulty.

The maze used was a high-relief finger-maze designed by Dr. Walter R. Miles. It was of the general type described by him in an earlier article (13). The design of the raised pattern was made of nickeled wire staples driven into a lacquered panel. The pattern was that used by Koch and Ufkess (11). The actual size of the maze was 12 x 12 inches and it had seven blinds. Each section was numbered consecutively, and the even numbers constituted the true path, hence the recording and interpretation of the path traced was simplified.

The subject was seated comfortably at a narrow table with the covered maze before him. The preliminary instructions were then given: "In this experiment you will learn the form of a raised pattern by passing your finger over it while your eyes are covered with a comfortable blindfold." The subject was then blindfolded in the manner described by Miles by means of goggles with adhesive tape on the inside of the lens. The goggles were lined afresh each time with absorbant paper in order to insure blindfolding around the edges and for sanitary precaution.

The hand that was not used in tracing was placed at the lower corresponding corner of the panel to insure constant orientation. For tracing the pattern the subject used the index finger of the hand with which he wrote. The finger was either flexed or extended as found most comfortable, and was applied to the maze at an angle of about 45 degrees, the other fingers were flexed as though pointing with the index finger The experimenter placed the subject's index finger on the "sample" section of the maze and, guiding the finger, instructed the subject thus

> This is the starting-point, a single hump This is the finishing point at the end of the path, a double hump All the paths that make up the pattern are just of this width and feel like this. They are made of nickeled wire staples driven into a lacquered panel This is a blind alley or a jump-off place and you feel how it comes to an end unconnected with any other path —Now we will make a trial on the pattern which you are going to learn Everyone requires several trials to learn how to go through the paths perfectly, that is, without going into any of the blind alleys In our results accuracy is somewhat more important than speed

The experimenter recorded the actual tracing of the path by the numbers on the divisions and recorded time by means of a stop-watch The criterion of learning was three consecutive correct tracings Other experimenters have used the same. Lashley's (12) findings indicate that prolonged training offers no advantages for reliability of results if the problem is a statistical comparison of different groups by a single standard of achievement He also found that three correct runs represented about the limit of training for white rats, basing his conclusions on a high positive coefficient of correlation between variations in the number of trials preceding the first correct run and variations in the number preceding six consecutive correct runs

The experimenter further recorded the introspective reactions of the subject as to the method of learning, i e , whether he learned the maze by giving himself verbal directions, by building up a visual image, or depended largely on kinaesthesis as a cue in determining the path traced The subject was also given a sheet of ordinary typewriting paper and asked to draw the path he had traced, and was encouraged to use both hands in the process The attempt in

this case was to get at spatial imagery, specifically to determine whether or not the individual recognized the general direction as represented by free-hand curves

Results

The data were analyzed by statistical methods legitimate for the number of cases. Central tendencies and variabilities are presented together with correlations computed by the rank-difference method This method was used since in each group one marked deviation tended to overshadow central tendencies In the matching of subjects chronological age was used in terms of the nearest year. It did not seem feasible to extend the matching to months since the exact date of birth of several of the blind students was not known. The pairs of subjects in chronological age correlated $.91 \pm .02$ and in intelligence test score, $.98 \pm .05$.

The maze-learning results in terms of total trials, total errors, total time, and average time are given for both the blind and the sighted groups in Table 3 The median chronological age for the blind group is seen to be 17.5, as compared with 17 for the sighted group, and the means are 17.6 and 17.5, respectively. The median test scores are identically the same, while the means differ by only 1 Hence it seems that the two groups are well matched so far as the two criteria are concerned and the results of their maze-learning activities should be comparable

The learning of the maze pattern by the two groups seems to be little differentiated so far as the criteria of learning employed are concerned. The medians for the blind group with regard to total trials, total errors, total time, and average time are 8, 12 5, 213 5, and 22 5, as compared with 9, 12, 162 5, and 22 5 for the sighted group. The only significant difference is in total time, in which the sighted group shows a decided superiority. The means for the same criteria of the blind group are 9 9, 18 9, 248.9, and 26 7, as compared with 10.4, 15.5, 245 6, and 23 6 for the sighted It is significant that the two means for the total time, 248 9 and 245 6, for the blind and sighted groups do not vary markedly, while the medians of this criterion of learning are 213 5 and 162 5, respectively. If the median is used as the basis of comparison the sighted group is decidedly superior in this respect, but if we use the means

Sub-ject	CA	Test score	Blind Trials	Blind Errors	Total time	Av time	Sub-ject	CA	Test score	Sighted Trials	Sighted Errors	Total time	Av time
6	20	70	8	21	168	21	1*s*	19	71	5	6	174	35
7	16	79	6	5	131	23	2*s*	16	80	6	5	149	25
13	16	49	6	9	128	21	3*s*	17	49	25	32	325	13
15	18	61	8	6	294	37	4*s*	18	61	6	7	152	25
16	17	91	9	13	326	36	5*s*	17	86	6	6	188	31
17	16	56	5	3	87	17	6*s*	17	52	11	19	263	24
18	17	71	6	9	131	22	7*s*	17	70	11	26	192	17
19	16	59	8	37	262	33	8*s*	16	58	15	37	415	28
23	15	54	11	13	323	29	9*s*	15	55	9	12	204	23
24	17	66	5	6	133	27	10*s*	17	67	9	5	174	19
26	19	62	14	42	417	29	11*s*	19	59	9	12	160	18
27	21	73	15	29	282	19	12*s*	19	74	5	2	101	20
28	16	56	14	22	298	21	13*s*	17	53	6	3	102	17
29	17	61	10	14	309	31	14*s*	17	62	22	63	506	23
31	16	48	12	102	552	46	15*s*	16	52	17	18	365	20
32	16	64	8	8	118	15	16*s*	16	63	9	13	221	25
33	16	52	16	64	783	48	17*s*	17	52	13	13	359	27
34	18	63	7	17	219	31	18*s*	18	63	8	10	147	18
40	20	44	12	13	208	17	19*s*	20	44	5	6	164	33
42	18	67	4	5	192	23	20*s*	18	66	9	33	135	15
44	19	64	8	7	151	19	21*s*	18	64	8	7	186	23
46	19	62	10	14	177	18	22*s*	18	62	15	22	314	21
47	19	46	6	6	127	21	23*s*	19	51	28	40	264	45
51	18	58	9	38	518	58	24*s*	17	60	6	5	233	39
53	18	70	11	11	241	22	25*s*	18	70	9	14	77	9
54	18	52	6	9	123	21	26*s*	18	52	8	10	176	22
55	17	45	12	13	402	33	27*s*	17	44	11	20	182	17
56	18	54	7	12	279	39	28*s*	18	53	3	0	120	40
57	17	67	7	9	62	9	29*s*	17	68	8	7	161	20
59	20	62	8	11	125	16	30*s*	20	62	10	12	158	16
Mean	17.6	60.9	9.9	18.9	248.9	26.7		17.5	60.8	10.4	15.5	245.6	23.6
Median	17.5	61.5	8	12.5	213.5	22.5		17	61.5	9	12.0	162.5	22.5
M D	1.2	7.3	2.5	13.7	118.7	10.8		1.13	7.3	4	10.3	116.4	6.25
S D	1.5	10.03	3.3	21.2	121.6	10.7		1.5	9.7	5	7.53	119.6	4.4
Q D	1.5	7	3	7	138.3	7		.5	7.8	3	4.8	56.5	4.8

there appears to be little difference, although the sighted make fewer errors and are a little quicker than the blind

It is possible that the maze pattern used presented so little difficulty to most subjects as to be inadequate as a learning problem If we examine the data with reference to trials to learn, we find that the average is 9.9 for the blind and 10.4 for the sighted group, as compared with Husband's (9) 16.7 in using a maze pattern presenting more possibilities of error. This would indicate that this particular pattern is not too easy if the criterion of average number of trials is accepted Knotts and Miles's (10) findings with a high-relief maze of the same pattern as that used by Husband were 49 and 38 trials to learn for the blind and sighted groups, respectively. In the total number of trials, the blind as a group are slightly superior both as to mean and median scores. The error scores show medians approximately the same for both groups, but the sighted group has the advantage of a slightly lower mean than the blind group. The difference amounts to 18 per cent.

Analyzing the data from the standpoint of individual records, we find little evidence of group differences The best record, from the point of view of the criteria employed, is that of Subject No. 28*s* of the sighted group, who had three trials, no errors, and a total time of 120 seconds, with an average time of 40 seconds. The explanation of no errors can probably be ascribed to chance. The best record from the time criterion is that of Subject No 57 of the blind group. This subject's total time is 62 seconds, with an average time of 9 seconds; yet his total trials and total errors are also significantly low, being 7 and 9, respectively. Considering individual cases from the point of view of poor performances the largest total time record, 1264 seconds, is that of a sighted subject, No 23*s*, who also has the largest average time record, 45 seconds, of the sighted group. This individual shows a record of 28 trials and 40 errors which is the second largest error score in this group, and is the largest trial score The individual score showing the largest number of errors is that of Subject No 31 of the blind group, with 102, as compared with a score of 63 for the sighted group. We see that total time as a criterion places the poorest score in the sighted group. The sighted group also has the poorest total trial score In general, it is seen than an analysis of individual records gives superiority to the blind group so far as good records are concerned; it is also true that more poor records are found in the sighted group.

Coefficients of Correlation

The correlations between chronological age, intelligence test scores, and the criteria of learning the maze pattern are given in Table 4

TABLE 4

Maze Scores Correlated with Chronological Age and with Intelligence Test Scores

	Intelligence test score	Trials	Errors	Total time	Av time
			Blind subjects		
CA	+ 20±.12	+ 08± 12	— 13± 12	—.07± 12	— 24± 12
Intelligence test score		— 18±.12	— 62± 08	— 49±.09	+ 25± 12
Trials			+ 81± 04	+.78± 05	+ 30±.11
Errors				+ 82± 04	+ 41± 10
Total time					+ 75± 05
			Sighted subjects		
CA	+ 06± 12	— 12± 12	— 24± 12	—.30± 11	+ 01± 12
Intelligence test score		— 30± 11	— 36± 11	— 39± 10	—.11± 12
Trials			+.86± 03	+ 73± 06	— 24± 12
Errors				+ 71± 06	— 29± 11
Total time					+ 33± 11

The correlations between trials and errors, trials and time, and errors and time for both groups are high, ranging from .71± 06 to .86± 03 The correlations between average time and other measures of maze learning employed range from — 29± 11 to + 33± 11 for the sighted group It would seem that average time is less significant as a measure of maze-learning ability than the other criteria employed

The intelligence test score has a higher degree of relationship with maze-learning ability than does chronological age. The coefficients of correlation are all negative for both groups, ranging from —.18±.12 to — 62±.08 for the blind and from — 30±.11 to —.39± 10 for the sighted group The negative coefficients in this case are to be interpreted as meaning that those with higher intelligence test score succeeded better in maze learning as indicated by a lower score. Chronological age shows coefficients of correlation of 08± 12, — 13± 12, and — 07± 12 with total trials, total errors, and total time, respectively, for the blind group, as compared with coefficients of — 12± 12, — 24± 12, and — 30± 11 for the sighted

group. The latter group of coefficients indicates that the older succeed slightly better than the younger The coefficients for the blind group are so small as to be negligible. For both groups the coefficients are smaller than in the case of the intelligence test scores.

Comparing these results with those of Knotts and Miles (10), which they obtained using a more intricate maze pattern, we see *that in both cases the coefficients of correlation between measures of* intelligence and criteria of maze learning are all negative for both groups, though those for the blind reported in this study are markedly lower than those reported by Knotts and Miles, in the case of the sighted the coefficients are slightly *higher than Knotts and Miles* have found Chronological age in both studies shows a negative relationship with maze scores for the sighted group, with coefficients of Knotts and Miles's study somewhat higher In the latter study chronological age for the blind group gives negative but low coefficients with maze scores, while those of this study are also significantly small and range from low positive to low negative The trends seem to be the same in both studies in spite of the difference in size of the coefficients Where the coefficients are negative in one case and positive in the other they are small enough to be negligible in both instances.

Rate of Learning

The number of errors in the first trial of the blind group is markedly greater than that for the sighted group· 172 as compared with 12 The next greatest difference is that of the fifth trial· 63 as compared with 31 At the sixth trial the two groups are approximately the same, and at the seventh the sighted group shows more errors· 15 as compared with 10. The eighth and ninth trials show the two groups approximately the same, and in the next three class intervals the blind group goes below that of the sighted No blind subject required more than 13 trials for mastering the maze, while one sighted subject required 25 trials. In other words, it seems that in the beginning the blind subjects find the learning problem more difficult, but by the time the sixth trial is reached they approximate the success of the sighted, and by the eleventh trial they surpass the sighted group. There is some indication that the blind, when near the middle of the learning, experienced an emotional dis-

turbance due to a growing feeling of failure which did not occur to such an extent in the sighted group

Analysis of Difficulties

There were very slight differences between the two groups with reference to frequency to entrance into each cul-de-sac Nos 1, 7, and 11 represent movement straight ahead, of which 11 gives the largest average number of errors for both blind and sighted. The second largest number of entrances is into No 1. For both groups alleys 1 and 11 are most difficult, alleys 3 and 7 relatively easy, alleys 5 and 9 represent neither the easiest nor the most difficult In one aspect these results are identical with those of Knotts and Miles (10), the sighted group is consistently slightly superior in regard to entrances into the various culs-de-sac.

Relation of Visual Experience to Maze Learning

In order to determine the relationship, if any, between quality and quantity of visual experience and ability to master the finger maze, the entire blind group of 59 subjects are presented in Table 5 classified according to their gross seeing ability, the length of visual experience, and the oculist's summation of their degree of sight The length of visual experience and the description of their gross seeing ability is expressed in terms which the individuals themselves used in describing their experiences These individuals were then divided into four classes Class I, those who have had perfect vision one year or more, now have imperfect, Class II, those who have had perfect vision, but now are blind, Class III, those who have had imperfect vision, but now are blind; Class IV, those who have always had and now have imperfect vision This classification is given in Table 6 The maze results of these individuals are also given in this table Within the classes the subjects are arranged in descending order according to degree of blindness The results of maze-learning criteria seem to substantiate the findings of others that in this type of problem visual experience does affect success of maze learning In other words, those who have had perfect vision and now are blind, Class II, are the most successful in the solution of the maze problem, these are largely individuals who have lost their vision through accident or disease A summary of Table 6 given below shows this tendency more clearly

TABLE 5

THE OCULIST'S REPORT, THE DESCRIPTION, AND THE DURATION OF THE VISION OF THE ENTIRE GROUP

Subject	Oculist's Report REV	Oculist's Report LEV	Description of degree of blindness	Duration of blindness
1	0	0	total	infection at one or two months
2	0	0	total	optic nerve affected at birth
3	0	0	total	meningitis at one year
4	0	0	total	shot through the head at fifteen, optic nerve severed
5	0	0	total	since three days old
6	0	0	total	since five years old
7	0	0	total	meningitis at 18 months
8	LP	0	light perception	meningitis at 15 months
9	LP	0	light perception	totally blind until nine years ago
10	LP	0	light perception, colors	eyes infected at birth
11	LP	0	light perception, colors	small-pox at five years of age
12	LP	0	light perception	birth; gradually growing worse
13	LP	0	light perception	since seven years of age
14	LP	0	light perception; objects	since six weeks old
15	0	LP	light perception	since early infancy
16	0	LP	light perception	infection at six years
17	0	LP	light perception, objects	stuck knife in eye when three years old
18	F 6 in	0	finger perception	meningitis at two years of age
19	0	F 1 ft	finger perception	congenital cataracts

TABLE 5 (*continued*)

Sub-ject	Oculist's Report REV	LEV	Description of degree of blindness	Duration of blindness
20	4/200	0	reads print	typhoid fever at five years
21	0	6/200	reads large print	cataract since birth
22	LP	LP	reads print some	since two months old
23	LP	LP	sees objects in room	cataract at birth
24	LP	LP	light perception	perfect vision until seven years of age
25	LP	LP	light perception	meningitis at six years
26	LP	LP	light perception	meningitis at three months
27	LP	LP	light perception	since one year old
28	LP	LP	reads large print some	birth
29	LP	LP	light perception	stuck knife in eye at four years of age; lost sight in both eyes
30	LP	LP	light perception	since ten years old
31	LP	LP	sees colors, objects	meningitis at seven months
32	LP	LP	light perception	infected eyes at sixteen months
33	LP	LP	light perception	congenital
34	LP	LP	sees colors; objects	congenital
35	F 3 in	0	light perception	since three years old
36	F 1 ft	LP	slight vision	since six months old
37	F 1 ft	F 1 ft	only light perception until ten years ago, now sees objects in room	optic nerve affected at three weeks
38	F 1 ft	F 1 ft	objects in room	only light perception until fifteen years of age
39	F 1 ft	F 1 ft	totally blind once, improving, reads large print	meningitis at twelve years of age
40	F 1 ft	F 1 ft	light perception, colors	read headlines until thirteen years of age

Subject	Oculist's Report REV	Oculist's Report LEV
41	F 1 ft	F 1 ft
42	F 2 ft	F 2 ft
43	F 3 ft	F 2 ft
44	F 2 ft	F 3 ft
45	F 2 ft	F 4 ft.
46	F 6 ft	F 6 ft.
47	F 6 ft	F 10 ft
48	LP	10/200
49	F 6 in.	5/200
50	3/200	F 1 ft
51	20/200	10/200
52	20/200	18/200
53	20/200	20/200
54	20/200	20/200
55	20/200	20/200
56	18/50	10/100
57	30/50	20/70
58	18/200	18/20
59	20/200	20/20

TABLE 5 (*continued*)

Description of degree of blindness	Duration of blindness
reads headlines in newspapers	since two months old
reads ordinary print; writes, very near-sighted	congenital
sees colors, objects	congenital
reads large print; dislocated lens	congenital
reads large print	scarred retina from measles at five years of age
reads print some	congenital optic nerve defect
double dislocated lens	congenital
reads print, sees colors	since eleven years old
reads large print	blind at six months, only sight perception from six months to seven years
reads some	infection at six months
reads print some	since six months old
reads ordinary print, nerve atrophy	through sixth grade in public school
sees objects, reads large print	congenital
reads ordinary print	gradually worse since seven years old
reads large print	scarlet fever at less than one year
reads print some	public school for six years
reads print	through fourth grade in public school
reads some	diphtheria at two years, settled in eyes
reads newspaper headlines, movie captions, etc	congenital, albino

Class I—have had perfect vision at least one year, now imperfect						
8	21	60	11	4	144	13
9	25	*	12	19	227	19
11	15	50	19	31	469	25
15	18	61	8	6	294	37
16	17	91	9	13	326	36
17	16	56	5	3	87	17
18	17	71	6	9	131	22
20	25		9	15	632	70
24	17	66	5	6	133	27
25	19	64	12	12	148	12
27	20	73	15	29	282	19
29	17	61	10	14	309	31
30	16		8	43	263	33
32	16	64	8	8	118	15
39	19		8	7	147	18
45	24		6	5	187	31
48	23		7	7	145	21
52	13		5	7	166	33
54	18	52	6	9	125	21
56	18	54	7	12	279	39
57	17	67	7	9	62	9
58	19	63	4	4	123	21
Mean	18 4	63 5	8 4	12 4	218 0	25 9
Median	18	63	8	9	157	21 5
Class II—have had perfect vision, now blind						
1	21	60	11	4	144	13
2	21	48	7	10	170	7
3	17		6	66	120	20
4	19	70	6	77	183	31
7	16	79	6	5	131	23
Mean	17 1	64 3	7 2	6 4	149 6	18 8
Median	17	65	6	6	144	20

*Blanks indicate that data in those columns were not available for that subject

Class II has the most desirable records from the point of view of both mean and median of all maze criteria recorded Class I ranks second, Class III third, and Class IV fourth according to the means of these criteria. Class III, consisting of only two cases, is out of consideration in terms of median, but was included in the consideration of means because it shows a general trend. In regard to medians, Class II again ranks first, Class I second, and Class IV

TABLE 6

GROUPING OF THE BLIND STUDENTS ACCORDING TO THEIR VISUAL EXPERIENCE

Subject	CA	Test score	Trials	Errors	Total time	Average time

			Means				
Class II	5	17 1	64.3	7 2	6 4	149.6	18 8
Class I	22	18 4	63 5	8 4	12 4	218 0	25 9
Class III	2	20	54	8	16	259	32 5
Class IV	30	18 1	55 5	10 2	23 3	275 6	26 1
			Medians				
Class II		17	65	6	6	114	20
Class I		18	63	8	9	157	21 5
Class III		18	58	8	12	207 5	22 5

TABLE 6 (*continued*)

Subject	CA	Test score	Trials	Errors	Total time	Average time
	Class III—have had imperfect vision; now blind					
5	20	38	8	11	350	44
6	20	70	8	21	168	21
Mean	20	54	8	16	259	32.5
	Class IV—have had and now have imperfect vision					
10	21		10	12	142	14
12	16		6	7	138	23
13	23	60	7	7	151	22
14	17	72	6	7	63	11
19	16	59	8	37	262	23
21	16	45	6	6	97	16
22	22		12	222	205	17
23	15	54	11	13	324	29
26	19	62	14	42	417	29
28	16	56	14	22	298	21
31	16	48	12	102	552	46
33	16	56	16	64	783	48
34	18	63	7	17	219	31
35	23		17	24	243	14
36	18		7	3	118	17
37	22	31	16	104	626	40
38	19		8	13	239	30
40	20	44	12	13	208	17
41	24	58	32	77	935	29
42	18	67	4	5	92	23
43	16	49	6	9	128	21
44	19	64	8	7	151	19
46	19	62	10	15	177	18
47	19	46	6	6	127	21
49	19	42	8	11	184	23
50	23	60	8	7	207	26
51	18	58	9	8	518	58
53	18	70	11	11	211	22
55	17	45	7	12	279	39
59	20	62	8	11	125	16
Mean	18 1	55 5	10 2	23 3	275 6	26 1
Median	18	58	8	12	207 5	22 5

SUMMARY OF TABLE 6

	No of subjects	CA	Test score	Trials	Errors	Total time	Average time

third. The only exception in either case is that of the mean average time score of Classes III and IV, here we find Class III taking fourth rank and Class IV taking third place In the case of median trial score, Classes I and IV are identical. The consistency of these tendencies is quite significant in so far as relationship of quality of visual experience and maze success is concerned.

An attempt has been made in Table 7 to represent maze learning in terms of the present degree of visual experience The entire blind

TABLE 7

THE BLIND STUDENTS ARRANGED ACCORDING TO THEIR DEGREE OF VISION

Subject	CA	Test score	Oculist's report REV	Oculist's report LEV	Maze results Trials	Maze results Errors	Maze results Total time	Average time
			Class I—blind in both eyes					
1	21	60	0	0	11	4	144	13
2	13	48	0	0	7	10	170	7
3	17	—	0	0	6	6	120	20
4	19	70	0	0	6	7	183	31
5	20	38	0	0	8	11	350	44
6	20	70	0	0	8	21	168	21
7	16	79	0	0	6	5	131	23
Mean	18.4	60.9			7.4	9.1	180.9	22.7
Median	19	65			7	7	168	21
			Class II—blind in one eye, light perception in the other eye					
8	21	60	LP	0	11	4	144	13
9	25	—	LP	0	12	19	227	19
10	21	—	LP	0	10	12	142	14
11	15	50	LP	0	19	31	469	25
12	16	—	LP	0	6	7	138	23
13	23	60	LP	0	7	7	151	22
14	17	72	LP	0	6	7	63	11
15	18	61	0	LP	8	7	294	37
16	17	91	0	LP	9	13	326	36
17	16	56	0	LP	5	3	87	17
Mean	18.9	64.1			9.3	10.9	206.1	21.7
Median	17.5	60			8.5	7	147.5	20.5
			Class III—blind in one eye, more than light perception in the other eye					
18	17	71	F 6 in	0	6	9	131	22
19	16	59	0	F 1 ft	8	37	262	23
20	25		6/200	0	9	15	632	70
21	16	45	0	6/200	6	6	97	16
22	22		4/20	0	12	22	205	17
Mean	18.8	58.3			8.2	17.8	265.4	29.6
Median	17	59			8	15	205	22

Mean	20.5	—			12	13.5	180.5	15.5
Class VI—finger perception in both eyes								
37	22	31	F 1 ft	F 1 ft	16	101	626	40
38	19		F 1 ft	F 1 ft	8	13	239	30
39	19		F 1 ft	F 1 ft	8	7	117	18
40	20	44	F 1 ft	F 1 ft	12	13	208	17
41	24	58	F 1 ft	F 2 ft	32	77	935	29
42	18	67	F 2 ft	F 2 ft.	4	5	92	23
43	16	49	F 3 ft	F 2 ft	6	9	128	21
44	19	64	F 2 ft.	F 3 ft	8	7	151	19
45	24		F 2 ft.	F 4 ft	6	5	187	31
46	19	62	F 6 ft	F 6 ft	10	15	177	18
47	19	46	F 6 ft.	F 10 ft	6	6	127	21
Mean	19.1	52.6			10.5	23.7	256.1	24.3
Median	19	53.5			8	9	177	21
Class VII—light perception in one eye, more than light perception in the other								
48	23	60	LP	10/200	7	7	145	20.1
Class VIII—finger perception in one eye, more than finger perception in the other eye								
49	19	42	F 6 in	5/200	8	11	284	23
50	23	60	3/200	F 1 ft.	8	7	207	26
Mean	21	51			8	9	245.5	24.5
Class IX—more than finger perception in both eyes								
51	18	58	20/200	10/200	9	38	518	58
52	13		20/200	18/200	5	7	166	33
53	18	70	20/200	20/200	11	11	241	22
54	18	52	20/200	20/200	6	9	125	21
55	17	45	20/200	20/200	12	13	402	33
56	18	54	18/50	10/100	7	12	279	39

TABLE 7 (*continued*)

Subject	CA	Test score	Oculist's report REV	Oculist's report LEV	Maze results Trials	Maze results Errors	Maze results Total time	Average time
		Class IV—light perception in both eyes						
23	15	54	LP	LP	11	13	324	29
24	17	66	LP	LP	5	6	133	27
25	19	64	LP	LP	12	12	118	12
26	19	62	LP	LP	11	42	117	29
27	20	73	LP	LP	15	29	282	19
28	16	56	LP	LP	14	22	298	21
29	17	61	LP	LP	10	14	309	31
30	16	—	LP	LP	8	43	263	33
31	16	48	LP	LP	12	102	552	46
32	16	64	LP	LP	8	8	118	15
33	16	56	LP	LP	16	64	783	48
34	18	63	LP	LP	7	17	219	31
Mean	17.1	60			11	31	323	28 +
Median	16.5	62			11.5	19.5	287	29
Class V—light perception in one eye and finger perception in the other eye								
35	23	—	F 3 ft	LP	17	24	213	14
36	18	—	F 1 ft	LP	7	3	118	17

TABLE 7 (*continued*)

Subject	CA	Test score	Oculist's report REV	Oculist's report LEV	Maze results Trials	Maze results Errors	Maze results Total time	Average time
57	17	67	20/50	20/70	7	9	62	9
58	20	63	20/200	18/20	4	4	123	21
59	20	62	20/200	20/20	8	11	125	16
Mean	18	58.9			7.7	12.7	226.7	26.9
Median	18	60			7	11	166	22

SUMMARY OF TABLE 7
THE BLIND STUDENTS ARRANGED ACCORDING TO THEIR DEGREE OF VISION

	No. of subjects	CA	Test score	Trials	Errors	Total time	Average time
Class I	7						
Mean		18.4	60.9	7.4	9.1	180.9	22.7
Median		19	65	7	7	168	21
Class II	10						
Mean		18.9	64.1	9.3	10.9	206.1	21.7
Median		17.5	60	8.5	7	147.5	20.5
Class III	5						
Mean		18.8	58.3	8.2	17.8	265.4	29.6
Median		17	59	8	15	205	22
Class IV	12						
Mean		17.1	60	11	31	323	28.4
Median		16.5	62	11.5	19.5	287	29
Class V	2						
Mean		20.5	—	12	13.5	180.5	15.5
Class VI	11						
Mean		19.1	52.6	10.5	23.7	256.1	24.3
Median		19	53.5	8	9	177	21
Class VII	1						
		23	60	7	7	145	20.1
Class VIII	2						
Mean		21	51	8	9	245.5	24.5
Class IX	9						
Mean		18	58.9	7.7	12.7	226.7	26.9
Median		18	60	7	11	166	22

group has been divided into the following nine classes: I, blind in both eyes, II, blind in one eye, light perception in the other, III, blind in one eye, more than light perception in the other, IV, light perception in both eyes, V, finger perception in one eye, light perception in the other, VI, finger perception in both eyes, VII, light perception in one eye, more than light perception in the other, VIII, finger perception in one eye, more than finger perception in the other, IX, more than finger perception in both eyes. Within these groups the subjects have been arranged in descending order according to degree of blindness, provided there is a difference, in Classes I, II, and IV there is no possibility for arrangement within the class.

Classes VI and IX include the most successful learners, Subjects 42 and 58, respectively, with four trials each, Class VI also contains the individual, Subject 41, with the largest trial score, 32. The least number of errors is that of Subject 17 in Class II, while the largest number is that of Subject 37 of Class VI. The longest total time record, 935 seconds, is that of Subject 41 in Class VI, the shortest, 62 and 63, are those of Subjects 14 and 57 of Classes II and IX, respectively

Thus it seems that the present degree of vision is of much less importance, so far as maze-learning ability is concerned, than the amount or duration of visual experience. And both these analyses tend to confirm the findings of Koch and Ufkess (11) and Knotts and Miles (10) that the extent and duration of blindness constitute an important factor in successful maze learning.

TABLE 8

METHODS OF LEARNING OF THE MATCHED BLIND AND SIGHTED GROUPS COMPARED WITH THE CRITERIA OF MAZE SUCCESS

Method	No	Trials	Errors	Total time	Av time
		Blind			
Verbal	14				
Mean		7 7	9 1	176 1	22.9
Median		8	9	132	21
Visual	5				
Mean		13 8	41 8	389	30 4
Median		12	29	282	22
Kinaesthetic	1				
Mean		12	13	402	33
Median					
Verbal-visual	9				
Mean		8 9	17.9	239 1	26 6
Median		8	14	219	29
		Sighted			
Verbal	14				
Mean		9.9	14 7	214 2	22 5
Median		9	12	179	22
Visual	8				
Mean		8 5	16	181	24 5
Median		8 5	19	153.5	21
Kinaesthetic	4				
Mean		19	24 5	522 5	25 5
Median		20	25.5	319.5	22
Verbal-visual	3				
Mean		7 3	7.3	184	25
Median		6	6	188	24

Methods of Learning

The records of the maze learning of both groups include an introspective report as to how the subject learned the maze, i e., as to whether his learning was largely verbal, visual, kinaesthetic, or a combination of any of these. Verbal learning is here characterized as that in which the individual gives himself directions, counts, etc, either aloud or silently; visual learning is that in which the individual forms a mental picture or visualizes the maze pattern, kinaesthetic is used to describe learning in which the subject said that he had a certain muscular "feeling" when he reached the place to turn.

Table 8 gives the comparative results for the matched blind and sighted groups, and Table 9 presents those for the total blind and sighted groups It is seen that almost half of each group in each case used the verbal method There is evidence in the case of each

TABLE 9

Methods of Learning of the Total Blind and Sighted Groups Compared with the Criteria of Maze Success

Method	No	Trials	Errors	Total time	Av time
		Blind			
Verbal	26				
Mean		15.4	16	229 6	24 3
Median		7	9.5	156 5	22
Visual	14				
Mean		9	23	257	26
Median		8	9	196 5	28 5
Kinaesthetic	8				
Mean		11 5	10.9	190 5	16 8
Median		11 5	12 5	216	20 5
Verbal-visual	11				
Mean		9 5	16 5	244 5	25 7
Median		8	13	219	23
		Sighted			
Verbal	21				
Mean		9	14 3	212 8	25 4
Median		8	11	176	23
Visual	9				
Mean		8 1	14 8	184 3	24 7
Median		8	10	149	25
Kinaesthetic	4				
Mean		19	24 5	522 2	25 5
Median		20	18	320	22
Verbal-visual	5				
Mean		7 2	10 4	177	24 8
Median		6	8	188	24

criteria of maze learning of the superiority of the verbal over the other methods of learning, except perhaps that a combination of verbal and visual is very successful

A further check-up on the learning of the individual was afforded by the drawing of the true path of the maze immediately after learning, while yet blindfolded. Of the total group of the blind, 15 failed to draw square corners or right angles, they drew the true path as a continuous curve. Of this number only one had had visual experience of as much as one year; the greatest degree of vision represented in this group was that of Subject 39 · REV 1 foot and LEV 2 feet Two of the total group of the sighted for whom we have maze-learning results failed to draw right-angle turns. The method of learning of the two sighted subjects was visual and kinaesthetic, respectively. The record of the first is superior from the point of view of all criteria, that of the other gives the longest total time for learning of any member of either group, and the second largest number of both errors and trials. It would seem that degree of blindness and amount of visual experience determine, to some extent at least, the concept of the maze derived from limited tactual experience

Summary

1 Fifty-nine blind subjects were used in obtaining data on maze learning and they were given the Chapman intelligence test

2. Two matched groups, one of 30 blind (selected from the 59) and the other of 30 sighted subjects, were studied The groups were matched on the bases of chronological age and intelligence test scores The data for age, intelligence, and visual experience are given

3 The means and medians of the maze criteria for the two matched groups vary little except in regard to total time, the median gives the superiority to the sighted group.

4. The error criterion differentiates between the two groups more markedly than does the trial criterion for both mean and median, the median total time criterion also differentiates the groups.

5 The sighted group has the wider range of performance in regard to the total time criterion, it included the poorest record found and the best record found

6 The intercorrelations of the scores for trials, errors, and time show coefficients ranging from 71 to 86 and appear equally high for both groups

7 Intelligence, as measured by the Chapman test, correlates with success in maze learning; it shows a higher degree of relationship with maze success than does chronological age

8 In the first trials the blind learned more slowly than the sighted, but near the end more rapidly.

9 The degree of difficulty for the various blind alleys seemed to be closely the same for both groups

10 Past visual experience was found to influence success in maze learning more than does the present degree of sight

11 Those who have had perfect vision for at least a year seem to be the most successful in learning the maze

12. There is evidence in the case of each criteria of maze learning for the superiority of the verbal over the other methods of learning, except perhaps when a combination of verbal-visual is used

13 Of the total blind group 15 failed to draw square corners in reproducing the maze Only one of this number had had visual experience of as much as one year, the greatest degree of vision represented in this group of 15 was that designated as finger perception

14. Two sighted subjects failed to draw square corners, one of these presented the poorest record of any subject in either group.

References

1 Bogardus, E S, & Hinke, F. G. Experiments on tactual sensations of the white rat *J Anim Behav*, 1911, 1, 125-137

2 Brown, M S, & Stratton, G M The spatial threshold of touch in blind and seeing children *J Exper Psychol*, 1925, 8, 434-442

3. Carr, H A Maze studies with white rats I Normal, II Blind, III Anosmic *J Anim Behav*, 1917, 8, 259-275, 277-294, 295-306

4 ——— The influence of visual guidance on maze-learning *J Exper Psychol.*, 1921, 4, 399-417

5 Chapman, J C A group intelligence examination without prepared blanks *J Educ Res*, 1920, 2, 777-780

6 Griesbach, H Vergleichende Untersuchungen uber die Sinnesscharfe Blinder und Sehender *Arch f d ges Physiol*, 1899, 64, 577-638, 1900, 65, 365-429, 523-573

7. HERON, W T Individual ability versus chance in the learning of the stylus maze *Comp. Psychol Monog*, 1924, 2, No 8 Pp. 60.

8. HUNTER, W S Correlation studies with the maze in rats and human beings *Comp Psychol. Monog*, 1922-1923, 1, No. 1, Pt 2 Pp. 37-56

9. HUSBAND, R W. Human learning on a four-section, elevated finger maze *J Gen Psychol*, 1928, 1, 15-28

10. KNOTTS, J. R., & MILLS, W R The maze-learning ability of blind compared with sighted children *J Genet Psychol*, 1929, 36, 21-50.

11. KOCH, H L., & UFKESS, J A comparative study of stylus maze learning by blind and seeing subjects *J. Exper Psychol*, 1926, 9, 118-131

12. LASHLEY, K S. The criterion of learning in experiments with the maze. *J. Anim. Behav*, 1917, 7, 66-70

13 MILES, W. R The high relief finger maze for human learning. *J. Gen. Psychol.*, 1928, 1, 3-14.

14 PERRIN, F. A. C. An experimental and introspective study of the human learning process in the maze *Psychol. Monog*, 1914, 16, No. 70 Pp. 97.

15. SEASHORE, C E Elemental tests in psychology. *J Educ Psychol*, 1916, 6, 81-85.

16. STRATTON, G. M Experimental psychology and its bearing upon culture New York & London. Macmillan, 1903. Pp vii+331.

17. TOLMAN, E. C The inheritance of maze-learning ability in rats *J. Comp Psychol*, 1924, 4, 1-18

18 VINCENT, S The white rat and the maze problem. *J Anim. Behav*, 1915, 5, 1-24, 140-157, 175-184, 367-374.

19. WARDEN, C. J The relative economy of various modes of attack in the mastery of a stylus maze. *J. Exper. Psychol*, 1924, 7, 243-275.

20 WATSON, J. B. Kinaesthetic and organic sensations their rôle in the reactions of the white rat to the maze *Psychol. Monog*, 1907, 8, No 33 Pp. vi+100

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UNE ÉTUDE COMPARATIVE DE L'APPRENTISSAGE DES LABYRINTHES DIGITAUX PAR LES SUJETS AVEUGLES ET NON AVEUGLES

(Résume)

Cette étude est une comparaison de la capacité à apprendre chez les sujets aveugles et non aveugles dans un problème ou les cubes tactiles sont dominants. L'outil a été un labyrinthe digital de haut relief de la forme de parcours employée antérieurement par Koch et Ufkess D'entre un total de 59 sujets aveugles étudiés dans ce labyrinthe on a choisi un groupe de 30 aveugles et ces sujets ont été comparés à 30 sujets non aveugles en termes de l'âge chronologique et des résultats des tests d'intelligence (Chapman) Les intercorrélations des résultats pour les épreuves, les erreurs et les durées montrent des coefficients qui varient de 0,71 à 0,86 et semblent

également élevées pour les deux groupes. Dans les premières épreuves les aveugles ont appris plus lentement que les non aveugles mais plus rapidement dans les dernières et le degré de difficulté des parcours a semblé à peu près le même pour les deux groupes. Dans les épreuves moyennes ou médianes pour apprendre les aveugles ont été un peu supérieurs aux non aveugles et comme groupe ils ont montré une exécution plus homogène que les non aveugles.

On a constaté que l'expérience visuelle antérieure influe sur le succès dans l'apprentissage d'un labyrinthe; ceux qui avaient préalablement joui d'une bonne vision pendant une année du moins ont semblé les aveugles qui ont le plus réussi à aprendre le labyrinthe. La supériorité de la méthode verbale aux autres méthodes s'est montrée. Le labyrinthe s'est composé de tournants à coins carrés, cependant 15 aveugles comparés à 2 non aveugles n'ont pas mis les coins carrés en reproduisant le labyrinthe de mémoire.

DUNCAN

EINE VERGLEICHENDE UNTERSUCHUNG ÜEBER DAS ERLERNEN EINES FINGERLABYRINTHS DURCH BLINDE UND SEHENDE VERSUCHSPERSONEN

(Referat)

Diese Untersuchung ist ein Vergleich der Lernfähigkeit blinder und sehender Versuchspersonen mit Bezug auf ein Problem, wobei die Tastmerkmale dominierten. Das Instrument war ein Hochrelieffingerlabyrinth eines Pfadmusters (path-pattern), wie es früher von Koch und Ufkess gebraucht wurde. Von insgesamt neunundfünfzig Versuchspersonen, die mit Hinsicht auf dieses Labyrinth studiert wurden, wurde eine Gruppe von 30 blinden ausgewählt, und diese Versuchspersonen wurden mit 30 sehenden Versuchspersonen nach chronologischem Alter und den Angaben eines Intelligenztests (Chapman) gepaart. Die Interkorrelationen der Angaben für Versuche, Fehler und Zeit weisen Koeffizienten vom Betrag 0,71 bis zu 0,86 auf und scheinen für beide Gruppen gleich hoch zu sein. In Erstversuchen lernten die Blinden langsamer als die Sehenden, aber gegen das Ende schneller, und der Schwierigkeitsgrad der Wege schien nahezu derselbe zu sein für beide Gruppen. Bei mittleren (mean or median) Lernversuchen waren die Blinden den Sehenden ein wenig überlegen, und als Gruppe war ihre Leistung homogener als die der Sehenden.

Seherfahrung in der Verangenheit beeinflusst den Lernerfolg im Labyrinth, diejenigen Blinden, die sich früher wenigsten ein Jahr lang guter Sehfähigkeit erfreuten waren am erfolgreichsten im Labyrinth.

Es wurde eine Überlegenheit der verbalen über andere Lernmethoden nachgewiesen. Das Labyrinth bestand aus rechtwinkligen Wedungen, aber 15 Blinde und 2 Sehende trugen beim Versuch, das Labyrinth aus dem Gedächtnis zu reproduzieren, keine rechtwinkligen Ecken ein.

DUNCAN

THE EFFECTS OF REPEATED AUDITORY STIMULATION UPON THE GENERAL ACTIVITY OF NEWBORN INFANTS*[1]

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INTRODUCTION

The history of neonate study reveals that the demonstration of sensitivity or lack of sensitivity has been the principal problem of most investigations in the auditory field. A great variability among infants and divers criteria of auditory sensitivity have contributed to this uncertainty At the present time, however, the evidence of auditory sensitivity during the first few days is quite conclusive, although newborn infants vary in the degree to which they are sensitive[2]

It has not yet been determined experimentally whether mechanisms exist at this age period which would make possible differential responses to the three characteristics of the auditory stimulus frequency, intensity, and purity. Most investigators agree, however, that the incidence of observable responses is greatest to high-pitched sounds. The frequency, as well as the extent and amplitude of the responses, bears a direct relation to the intensity of the stimulus, but this relation has not been systematically investigated Objective measurement of the movements of newborn infants to auditory stimuli has been made (15), but the stimulating devices used did

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[1]The material of this paper was, in part, presented before Section I of the American Association for the Advancement of Science, December, 1932, in Atlantic City The investigation was undertaken and completed at Ohio State University in 1930-31 while the writer was a Fellow of the National Research Council It is his desire at this time to acknowledge indebtedness to the Council, to the late Dr A P Weiss, who served as his director, to the Graduate School, to Dr Andrews Rogers and the University Hospital, to the Department of Psychology, to Mr I. L. Hampton, the laboratory technician, to Mr Charles Hu, who acted as assistant, and to all other individuals who aided in making the work possible.

[2]Evidence dealing with auditory sensitivity and some of the factors making for relative insensitivity are presented in the chapter on "The Neonate" in *A Handbook of Child Psychology*, 2nd ed, rev (14)

not provide for the control and separate variation of the auditory characteristics. When control of the stimulus has been effected (4) the frequency of response and its "pleasantness" or "unpleasantness" have received only qualitative observation

The most conspicuous pattern of response to auditory stimulation has been variously designated as the "fear" (*Schreck*) reaction (16), the "primary emotion of fear" (17), the "shock" reaction (7), and as essentially the Moro *Umklammerung* reflex (11). The pattern of response comprises an extension and abduction of the extremities followed by a return through adduction and flexion to the usual postures. As the extremities extend, the digits extend with *signe d'éventail* (fanning), the movements of arms and fingers often being slow and characterized by athetosic peculiarities. Accompanying this, there is a jerk or start of the entire body, which is in part due to the vigorous extension of the extremities and in part to the innervation of the musculature of the trunk. Associated with this complex there are cochlear-palpebral reflexes, involving a blinking if the eyes are open, or a further tightening of the lids if they are closed. Implicit responses occur in respiration and circulation, but are of short duration, similar in that respect to the explicit responses

If the stimuli are intense they may be followed by awakening from sleep and by crying.

The Moro component presents all degrees of activity, ranging from the involvement of all the extremities and trunk musculature to a response involving toe or finger movements accompanied by the cochlear-palpebral reflex This variability is a characteristic of different infants The reduction in the extent and vigor of the response also depends upon the previous stimulating conditions, and especially upon the interval between stimuli.

The responses just described depend upon a relatively quiescent organism. If the same auditory stimuli are presented while other activity is in progress, either there are no visible effects or the effects are inhibitory in character

A systematic investigation of the effects of continuous auditory stimulation has yet to be undertaken Most investigators find evidence of inhibitory effects if the stimuli are of long duration (as in musical sounds) If these stimuli are of short duration (as in noises) the effects are excitatory When Haller (4), studying

older infants, employed controlled continuous stimulation of 10 seconds' duration the responses started at the onset of the stimulus and began to disappear before the stimulus ceased.

Beyond noting the decline in effectiveness of a repeated auditory stimulus, the literature seems neither to indicate the extent of that decline nor its relation to *the interval of separation* between stimuli. Superficial observation of Canestrini's (2) curves of respiration and of brain volume at the fontanelle, as well as Peiper's (9) study of the "fear" reaction *in utero*, demonstrates that a decline does occur. To Peiper and Canestrini this is evidence of inhibition rather than of fatigue or adaptation.

The Problem

The purposes of this research were: (1) to obtain objective, quantitative measures of the effects of repeated auditory stimuli upon the activity of newborn infants; (2) to discover whether the effects are specific or general, or both of these; (3) to determine the relation of total activity to the number of stimuli per unit time, (4) to ascertain the effects of fatigue, adaptation, or inhibition upon activity; (5) to test the effectiveness of electrical counters in recording activity as compared with graphic records showing not only *frequency* but also *magnitude* and *time* relations of the responses.

Apparatus

Restriction and partial control of the environment is provided by the movable experimental cabinet[3] which houses the thermostatically controlled heating unit, the stabilimeter (a padded platform resting upon roller-bearings and held in the position of equilibrium by springs), and various stimulating devices. The child rests upon the stabilimeter which moves when the infant moves either as a whole or in some major segment.

As the movements of the child in the two dimensions (head-foot and right-left) disturb the equilibrium position of the stabilimeter, these movements are transmitted through a system of levers to the recording pens of a Renshaw-Weiss polygraph, which, together with

[3]For complete description and diagrams of this apparatus and the stabilimeter-polygraph unit a previously published work (15) may be consulted.

the various controls, is mounted on the *exterior* of the experimental cabinet

This polygraph tape graphically and permanently recorded all aspects (time relations, frequency, and magnitude) of activity, and electrical contacts on the polygraph-pen bars provided that a circuit through a given electrical counter be completed with an excursion of 2.5-3 mm from the base or equilibrium line. This recorded part of the frequency aspect of the stabilimeter oscillations[4] The bank of electrical counters was so housed and mounted as to eliminate auditory stimuli

Auditory stimuli were produced by mounting a cylindrical tin can, approximately 7 inches in length and 5 inches in diameter, in such a manner that activation of an electromagnet caused a plunger to strike against the bottom of the can Stimuli from such a source, while of moderate intensity, had previously been found effective in releasing responses. An auditory stimulus thus produced was for practical purposes constant and was of short duration, since it was quickly damped. The device was placed about one foot from the infant's head in the median axis of the body With the closing of one of the control switches, auditory stimuli would be provided automatically at intervals of 10, 30, or 60 seconds as desired, the timing for this and for the signal pens of the polygraph being accomplished through an interval timer operated by the synchronous motor The latter operated on A C. current, and the signal-pen magnets, electrical counters, and stimulating apparatus were operated on an ordinary Ford storage battery which was kept charging during experimentation so as to prevent an appreciable decline in efficiency. Since the magnets of the various devices were not of uniform resistance, it was found necessary to balance the system through rheostats.

Technique

The individualized treatment of each child with respect to hygienic precautions previously determined (15) in conjunction with the hospital authorities was again employed Formerly, sleeveless

[4]The use of one electrical counter to record oscillations for both of the stabilimeter dimensions not only restricted the number of oscillations recorded, according to size, but made it possible to record only one component at a given time, thus, if, while movement in the head-foot dimension was taking place, a simultaneous movement in the right-left dimension occurred, it would not be recorded

gowns had not been part of the child's regulation dress. It was decided that since the investigation was concerned with relative rather than absolute measures of activity and since a sleeveless gown restricts only the extent of the excursion of the upper extremities, it would be preferable not to stimulate the infant to the extent of removing this article of clothing.

Infants were selected according to nursery conditions and the state of activity of the baby. A child crying continuously or *wet* would not be selected during that particular period of experimentation. Similarly, a child developing continuous crying during the experimental investigation would be returned to the nursery.

The entire experimental procedure for each infant included the following three periods:

1. First, an adaptation period of two minutes when the child was placed on the stabilimeter in the experimental cabinet, a period designed to exclude from consideration any excitatory effects due to the transfer from bassinet to cabinet.

2. Then, according to the schedule arranged for the day, either a control period (CP) or an experimental period (EP) proper, the control period being a 10-minute period during which the activity was automatically recorded on the polygraph tape, the experimental period proper a 10-minute period during which auditory stimuli were given every 10, 30, or 60 seconds according to the scheduled program, the activity being recorded as before.

3. Lastly, if the second period was a control period, the third became an experimental period, and vice versa.

In addition to the polygraph record of all phases of activity, one electrical counter was utilized in recording the frequency of oscillations during the adaptation period, another during the control period, and one during the experimental period.

Results

In other studies (12, 13, 15) the general activity of a period was expressed in terms of (t/T) 100, where t is the time the infant is moving and T is the total time of the period. This is a satisfactory index when used in the study of activity at different ages and under different physiological conditions. It is not, however, sufficiently precise to equate the effects of specific stimulation, either in general

or in particular aspects The number of stabilimeter oscillations (5) is much more suitable for the present study

This index, i.e., the number of oscillations, makes it possible to compare number of oscillations per unit time in a control period with the number per unit time in an experimental period during which auditory stimuli occur at specified intervals It also enables determination of the number of oscillations per stimulation, thus throwing light upon the relation of activity to the length of interval separating stimuli and upon the relation of activity to successive repetitions.

Furthermore, study of the amplitude of the oscillations should furnish information regarding the effects of repeated stimulation.

This research was not undertaken for normative purposes, and the values for activity in control periods must not be considered as necessarily typical of a similar selection made upon a similar basis The activity values pertaining to such periods are rather to be considered in their relation to the experimental periods that just preceded or followed the corresponding activity periods. The possibilities of differing physiological states are so numerous that comparison of activity experimentally aroused with so-called "spontaneous" activity would otherwise be impossible It should be realized that studies of infant behavior have scarcely progressed beyond a statistical treatment of *frequency*, which, although quite variable itself, is less so than a quantitative measure of the reaction itself The exceptions to statistical studies of frequency of response alone are those dealing with reaction-times, as, for example, Peiper's (10) work Before greater reliability of quantitative measures of activity can be attained, it will be necessary to devise more analytical and precise means of differentiating physiological conditions so that a selection may present greater uniformity in these respects

An examination of the data presented in the subsequent tables will show all distributions to be skewed toward the 0-value of activity as dependent upon the limits of the registering devices This, in the experimental periods, may be attributed to the relative auditory insensitivity of some infants and to a decline in the effectiveness of the stimulus But, since the same condition obtains in the control periods, we are forced to conclude that the causes for this skewness are basically physiological In short, the tremendous range of activity in control periods is indicative of a variety of effective

physiological conditions among some infants. These differences may be due in part to differences in the time of experimentation with reference to time of feeding. The "asleep and dry" group shows markedly less activity in both control and experimental periods, with the differences between the periods much more clear-cut. Computing the P.E. of the differences of the medians rather than of the means lowers the reliability of the difference but does not significantly change the general picture. In other words, experimentally aroused activity rests upon the base of the existing state of irritability.

TABLE 1

NUMBER AND DISTRIBUTION OF INFANTS ACCORDING TO SEX, RACE, AND AGE; NUMBER AND TYPES OF EXPERIMENTS

		Counter records	Polygraph records
A	No.	27	28
	Age		Range 2-11 days, Av. 6 days
	Sex		Males 12, females 16
	Race		Whites 5, Negroes 22, Chinese 1
B	Complete	68	60
	Not complete	29	31
C	CPEP	34	29
	EPCP	34	31
D	10 sec	22	19
	30 sec	24	20
	60 sec	22	21

Legend.

A, number and distribution of infants

B, number of auditory experiments

C, distribution of experiments according to sequential order of control and experimental periods

D, distribution of experiments according to interval of stimulation

Complete, experiments in which both control and experimental periods are completed

Not complete, experiments in which either control or experimental periods are unfinished

CPEP, control period of 10 minutes (during which no stimuli are given) precedes experimental period of 10 minutes (during which auditory stimuli are given)

EPCP, experimental period precedes control period

Table 1 shows that:

1. The sexes have about equal representation in the group of infants studied, but the make-up of the group is almost exclusively Negro. Quantitative measurement of general activity reveals no

TABLE 2

ACTIVITY PER UNIT TIME IN COMPLETED CONTROL AND EXPERIMENTAL PERIODS ACCORDING TO PHYSIOLOGICAL OR NURSERY CONDITIONS AND TO THE SEQUENTIAL ORDER OF CONTROL AND EXPERIMENTAL PERIODS

		No	Range	S D	Mean	P E	Diff of M's	PE_{diff}	$\frac{Diff}{PE_{diff}}$
A	CP	60	0-27 10	6 32	5 24	55	2 66	93	2 86
	EP	60	0-49 30	8 62	7 90	75			
B	CP	29	0- 8 50	2 48	2 57	31	1 66	53	3 13
	EP	29	0-14 20	3 51	4 23	44			
C	CP	31	0-27-10	7 74	7 66	93	3 60	1 56	2 30
	EP	31	0-49 30	10 44	11 26	1 26			
D	CP	29	0-25 40	4 82	4 18	60	4 56	1 20	3 80
	EP	29	0-35 30	8 40	8 74	1 05			
E	CP	31	0-27 10	7 32	6 24	88	88	1 37	60
	EP	31	0-49 30	8 74	7 12	1 06			

Legend

No, number of experiments
Range, stabilimeter oscillations per minute
CP (control period), 10-minute period during which no stimuli were given
EP (experimental period proper), 10-minute period during which auditory stimuli were given
A, activity per unit time in all complete control and experimental periods
B, activity per unit time under the conditions *dry* and *asleep*
C, activity per unit time under the conditions *wet* or *awake*
D, activity per unit time with order of experimentation CP first, EP second
E, activity per unit time with order of experimentation EP first, CP second

significant race difference (13), but whether auditory sensitivity is the same will require a further analysis of the data treated by Gatewood and Weiss (3). Qualitative protocols of experimental periods seem to indicate sex and race differences in the frequency with which certain types of response occur, and an increase in their number in experimental periods during which stimuli of different modalities were applied.

2 *There is no representation in the group of infants on the day* of birth nor upon the following day, and that the study does not extend beyond the 11th day.

3. Of the experiments initiated, about one-third are not completed because of too great activity and continued crying or need for care in the nursery, etc

Table 2 shows that:

1 In all completed periods there is greater activity during an experimental period (EP) than during a control (CP) The mean for EP is 7 90, for CP, 5 24, the difference of the means/P.E of the difference being 2.86.

2 The effects of auditory stimulation are more apparent under the conditions "dry and asleep" The mean for EP is 4.23, of CP, 2.57, the difference of the means/P E. of the difference being 3 13.

3 The effects of auditory stimulation are superimposed upon the existing higher activity of the conditions "wet or awake" The mean of EP is 10.26, of CP, 7.66; with the difference of the means/P.E. of the difference equalling 2 30.

4. *When the EP follows the CP the differences in activity are* accentuated The mean of EP is 8 74, of CP, 4 18, with the difference of the means/P E of the difference equal to 3 80

5 When the EP precedes the CP the difference in activity is lessened The mean of EP is 7 12, of CP, 6.24, and the difference of the means/P E. of the difference is 0 60

Table 3 *shows that:*

1 Experimental periods following control periods present more activity than when they precede control periods The difference is not statistically reliable, for the difference of the means/P E. of the difference is but 1.08, the mean being for EP of CPEP, 8 74, of EPCP, 7 12.

2. Control periods following experimental periods contain greater

activity than when they precede experimental periods. The mean of CP in CPEP is 4.18; of CP in EPCP, 6 24, with the difference of the means/P E. of the difference equalling 1.94.

TABLE 3

COMPARISON OF ACTIVITY PER UNIT TIME UNDER PHYSIOLOGICAL OR NURSERY CONDITIONS AND ACCORDING TO EXPERIMENTAL PROCEDURE

	Mean	Diff of M's	P.E $_{diff.}$	$\frac{\text{Diff}}{\text{P E}_{diff.}}$
EP (CPEP) EP (EPCP)	8 74 7.12	1 62	1 49	1 08
CP (CPEP) CP (EPCP)	4 18 6 24	2 06	1 06	1 94
CP (CPEP) All EP	4 18 7 90	3 72	96	3 87
CP (CPEP) EP (EPCP)	4 18 7 12	2 94	1 21	2 42
EP (*wet* or *awake*) EP (*dry* and *asleep*)	11 26 4.23	7 03	1 33	5 28
CP (*wet* or *awake*) CP (*dry* and *asleep*)	7 66 2 57	5.09	98	5 19

3 Activity is greater in an experimental period preceding a control period than in a control period preceding an experimental period. The mean of EP in EPCP is 7 12, of CP in CPEP, 4 18, the difference of the means/P E. of the difference is 2 42.

4 Activity in control periods of CPEP order is significantly less than that of all experimental periods, since the difference of the means/P E of the difference is 3 87

5 In both control and experimental periods activity under the conditions *wet* or *awake* is almost three times as great as under the conditions *dry* and *asleep* The mean of EP (*wet* or *awake*) is 11.26, of EP (*dry* and *asleep*), 4.23, the difference of means/P.E. of the difference is 5 28, of CP (*wet* or *awake*), 7 66, of CP (*dry* and *asleep*), 2 57, and the difference of means/P E of the difference is 5 19

Table 4 shows that

1 Activity as recorded by electrical counters shows essentially the same relationships between control and experimental periods

TABLE 4

ACTIVITY PER UNIT TIME, AS RECORDED BY ELECTRICAL COUNTERS, IN COMPLETED CONTROL AND EXPERIMENTAL PERIODS AND ACCORDING TO THE SEQUENTIAL ORDER OF THESE PERIODS

		No	Range	S D	Mean	P E.	Diff of M's	P E $_{diff}$	$\frac{\text{Diff}}{\text{P.E}_{diff}}$
A	CP	68	0- 7 60	1 59	1 02	13	54	21	2.57
	EP	68	0-10 00	2 12	1 59	17			
D	CP	34	0- 2 90	.57	49	06	1 11	25	4 44
	EP	34	0-10 00	2 17	1 60	25			
E	CP	34	0- 7 70	2 04	1.54	23	04	33	12
	EP	34	0- 8 90	2 08	1.58	24			

Legend Same as Table 2

TABLE 5

ACTIVITY PER UNIT TIME IN COMPLETED EXPERIMENTAL PERIODS WITH SPECIFIC REACTIONS TO AUDITORY STIMULI SUBTRACTED AND ACCORDING TO PHYSIOLOGICAL OR NURSERY CONDITIONS AND TO SEQUENTIAL ORDER OF CONTROL AND EXPERIMENTAL PERIODS

		No	Range	S D	Mean	P E	Diff of M's	PE_{diff}	$\frac{Diff}{PE_{diff}}$
A	CP				5 24				
	EP	60	0-46 10	7 98	5 34	69	10	88	11
B	CP				2 57				
	EP	29	0- 8 20	2 10	2 40	26	17	40	42
C	CP				7 66				
	EP	31	0-46 10	10 18	8 04	1 23	38	1 54	24
D	CP				4 18				
	EP	29	0-35 30	7 36	5 70	92	1 52	1 09	1 39
E	CP				6 24				
	EP	31	0-46 10	8 48	5 00	1.02	1 24	1 34	92

Legend

No, *Range*, and *CP* same as in Table 2
EP, activity in experimental period proper minus specific reactions to auditory stimuli
A, non-specific activity in completed experimental periods
B, non-specific activity under the conditions *dry* and *asleep*
C, non-specific activity under the conditions *wet* or *awake*
D, non-specific activity with order of experimentation CP first, EP second
E, non-specific activity with order of experimentation EP first, CP second

as do the values obtained from the polygraph records. In the completed periods the mean of CP is 1.02, of EP, 1.59; the difference of the means/P.E. of the difference being 2.57, in periods with order CPEP the mean of CP is 0 49; of EP, 1.60, and the difference of the means/P E of the difference is 4.44

2. The ratio of mean of EP to mean of CP of counter values as compared with polygraph values is as follows

	Counter	Polygraph
A	1 55	1 50
D	3.26	2 09
E	1 02	1 14

Table 5 shows that.

1 When specific reactions to auditory stimuli are subtracted from the activity of the experimental periods the differences between these and the control periods become insignificant. In all completed periods the mean of CP is 5 24, of EP-Sp R's, 5 34, the difference of the means/P E of the difference is 0.11; under the conditions *dry* and *asleep* the mean of CP is 2.57; of EP-Sp R's, 2 40, with the difference of the means/P E. of the difference equalling 0 42, under the conditions *wet* or *awake* the mean of CP is 7 66, of EP-Sp.R's, 8.04, and the difference of the means/P.E. of the difference is 0.24

2. Apart from external stimulation, there is a tendency for activity to be greater in the second half than in the first half of a 20-minute period Thus with the order CPEP the mean of CP is 4 18, of EP-Sp.R's, 5.70, and the difference of the means/P E. of the difference is 1.39; with the order EPCP the mean of CP is 6 24; of EP-Sp.R's, 5.00; with the difference of the means/P.E. of the difference equalling 0 92

Table 6 shows that.

1. The total activity of experimental periods is increased when the number of stimuli is increased from one every 60 seconds to one every 10 seconds (the mean of the 60-second interval is 5.96, of the 30-second interval, 8 80, and of the 10-second interval, 9.10), although statistical reliability is approached only in the difference between the 60- and 10-second intervals.

2 From 60- to 10-second intervals the stimuli increase 6 times while activity increases only 1.52 times (i.e., 9.10/5.96).

TABLE 6

COMPARISON OF ACTIVITY PER UNIT TIME IN COMPLETED EXPERIMENTAL PERIODS ACCORDING TO INTERVAL OF AUDITORY STIMULATION

	Interval	Mean	Diff of M's	PE_{diff}	$\frac{Diff}{PE_{diff}}$
EP	10 sec 30 sec	9.10 8.80	.30	2.19	.13
EP	30 sec 60 sec.	8.80 5.96	2.84	1.70	1.67
EP	10 sec 60 sec	9.10 5.96	3.14	1.56	2.01

3. From 30- to 10-second intervals the stimuli increase 3 times while activity increases only 1.03 times (i.e., 9.10/8.80).

4. From 60- to 30-second intervals the stimuli increase 2 times while the activity increases only 1.47 times (i.e., 8.80/5.96).

TABLE 7

SPECIFIC AUDITORY RESPONSES OF EP'S

	Every 10 sec		Every 30 sec		Every 60 sec	
Successive minutes of EP	O per S	mm per O	O per S	mm per O	O per S	mm per O
1st	2.08	2.08	3.25	1.76	2.38	1.89
2nd	1.06	2.19	1.17	1.46	.47	2.82
3rd	.64	1.39	1.22	1.51	2.04	1.37
4th	.48	1.30	.42	2.17	.85	1.28
5th	.51	1.47	.45	1.61	1.00	1.57
6th	.73	1.35	.75	2.13	1.00	1.23
7th	.31	1.61	.75	1.56	2.04	1.93
8th	.70	1.72	.02	1.00	1.52	1.84
9th	.67	1.64	.40	1.62	1.71	1.61
10th	.61	1.28	.95	1.34	1.28	1.33
Total period	.79	1.73	.94	1.66	1.43	1.66

Legend *O*, oscillations, *S*, stimulus, *mm*, millimeters

Table 7 shows that:

1. Both characteristics of activity, number of oscillations per stimulus and the average magnitude of each oscillation, tend to decrease through the successive minutes of the experimental period, the greatest decrease being registered in the number-of-oscillations-per-stimulus characteristic of activity

2. The effect of changing the interval between stimuli is to alter the number of oscillations per stimulus characteristic rather than to affect the average magnitude of the oscillation. Thus the average number of oscillations per stimulus when the stimuli occur every 10 seconds is 0.79, when they occur every 30 seconds it is 0.94, and with one every 60 seconds it is 1.43. The respective average magnitudes are 1.73, 1.66, 1.66.

3. When auditory stimuli are spaced 60 seconds apart each stimulus is individually more effective in releasing responses than when the intervals are shorter.

TABLE 8

MILLIMETERS PER OSCILLATION

	All complete	Asleep and dry	Awake or wet
CP	1.54	1.45	1.57
EP	1.55	1.53	1.55
EP-Sp R's	1.47		
Sp R's	1.71		

Table 8 shows that:

1. In dealing with all completed auditory periods there appears to be no difference in the average magnitude of oscillations of control periods (1.54) as compared with experimental periods (1.55).

2. Under the conditions *asleep* and *dry* a difference, whether significant or not, appears. The average magnitude for CP is 1.45, for EP it is 1.53.

3. The average magnitude of the oscillations in experimental periods with the specific reactions to auditory stimuli subtracted is only 1.47, thus resembling the CP value of the *asleep* and *dry* state.

4. The average magnitude of the specific reactions is 1.71, indicating that the pattern of auditory response occasions greater excursions of the stabilimeter than occur in "spontaneous" movements of the same period of experimentation.

DISCUSSION

Auditory stimuli of the type employed in this research are, according to Watson (17), adequate for the arousal of the primary emotion of "fear." Emotion he defines as "an hereditary pattern re-

action involving profound changes of the bodily mechanism as a whole, but particularly of the visceral and glandular systems." The significance of this definition, as well as that of other characterizations of emotion, is that responses of some duration are implied Woodworth's (18) "stirred-up state of the organism" is a case in point Yet a review of the literature upon the neonate discloses, in most cases, no such sustained activity in response to auditory stimulation. Haller (4), using stimuli of 10 seconds' duration, although classifying responses upon the basis of "feeling-tone" characteristics, nevertheless reports that the responses occur at the onset of stimulation and begin to decline before the stimulus has ceased. Peiper (10) finds the pattern of responses described in the present paper to be elicitable without awakening the child or causing it to cry. The reaction-times are short. Similarly, Canestrini (2) shows that certain of the effects produced through the autonomic system, e g , changes in respiration and circulation, are likewise quickly produced and of short duration.

In short, the extremely variable pattern of responses to auditory stimuli is characterized by a quickness of occurrence and a duration too brief to warrant its classification as an "emotion"

The relatively insignificant rôle of auditory stimuli in the releasing of activity, compared to that produced by the physiological conditions that characterize the *wet* or *awake* states, is clearly in evidence even in Table 3 Sustained activity in which most of the organism participates is correlated largely with activity along the alimentary canal or with certain environmental temperatures that may affect the body either generally or locally.[5]

According to Irwin's (5) thesis, these responses to auditory stimuli should represent individuation from "mass" behavior But since Irwin's data, as well as those of other investigators, indicate quite clearly that this "mass" or "spontaneous" behavior arises in connection with activity along the alimentary tract, the hypothesis of "mass" behavior as the "matrix" appears questionable Studies of fetal behavior by Minkowski (8) and others show no evidence of the "mass" behavior described and studied by Irwin According to the latter (6), one of the main criteria of specific movements as opposed to "mass" behavior is their *slowness*, on the average This

[5]The nature of the variously termed "random," "spontaneous," "mass" behavior is considered at greater length in "The Neonate" (14)

is exactly the principal characteristic of fetal movements either in the early stages, as studied by Minkowski, or later in premature infants, as shown by the investigations of Bersot (1) and others It is known indirectly that a certain amount of peristalsis occurs during the fetal stage, but this does not appear to be related significantly to fetal activity. Furthermore, before there is any evidence of the so-called "mass" behavior, the major component of the auditory response, as Peiper (9) shows, may be elicited *in utero*.

The question arises as to whether the responses to auditory stimuli may adequately be described as *generalized* or *specific* The writer has previously noted[6] the indefinite character of these terms. It has been general usage to treat as specific those responses which are localized and as generalized those which are unlocalized. But this simply means that a given response will be considered as generalized or specific according to the point of reference Again, specificity of response has been made to refer to high frequency of occurrence in response to a particular stimulus, regardless of the extent of the response, and still further to refer to a *unique* connection between a particular stimulus and a particular response

From the standpoint of localization the auditory responses present, according to the experimenter's protocols, all degrees of localization, varying from infant to infant and from stimulus to stimulus, between extreme limitation among explicit responses such as palpebral reflexes and toe and finger reflexes, to activity in practically all segments of the body

From the point of view of frequency of occurrence the responses range from those which are most invariable, like the cochlear-palpebral reflex, to those which appear rarely, such as the extension of the big toe alone.

And, as Watson (17) and Peiper (11) have demonstrated, there is no unique relation between the auditory stimulus and the obtained responses.

Lastly, we have to account for the reduction and even the disappearance of most of the responses when the auditory stimuli are repeated at short intervals. This diminution of the response has been attributed to adaptation, but this interpretation does not seem tena-

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[6]Generalization and specificity of behavior in the new-born infant *Psychol Bull*, 1931, 693-694 A paper presented before the American Psychological Association at Toronto, September, 1931

ble, since we are not dealing with continuous stimulation Each of Haller's (4) stimuli lasted 10 seconds but usually the response began and ended before the stimulus ceased. With abrupt stimulation such as was employed in this research, the possibility of adaptation as ordinarily understood seems quite remote. It might be argued that repeated stimuli have a cumulative effect approaching the adaptation to a continuous type of stimulation. This seems doubtful in view of the fact that the response does not remain completely in abeyance after the first few stimuli but may recur at intervals during the remainder of the experimental period.

This latter phenomenon which will be treated in a subsequent paper seems also to make the hypothesis of fatigue untenable

There remain theories assuming some type of inhibition, as advanced by Canestrini (2) and Peiper (9). The former noticed this reduction in activity brought by repeated stimuli in his circulatory and respiratory indices. The latter, studying the so-called "fear" component *in utero*, reports the same reduction of response The inhibitory effects of auditory stimuli (particularly those of some duration) upon existing activity have already been mentioned

Conclusions

The following conclusions seem justifiable:

1. The gross total activity is increased during the periods in which a baby is subjected to auditory stimuli

2. The excitatory effects are much more pronounced when other stimulating conditions (particularly those associated with the functions of the digestive tract) are not present

3 Electrical-counter readings give essentially the same values as the polygraph records

4. Increased activity of the periods of auditory stimulation is the result of the immediate responses to the individual stimuli rather than being the product of a heightened general irritability and restlessness It therefore seems unwise to designate the overt patterns of response as an "emotion" of "fear," since "emotion" usually connotes "a stirred-up state of the organism" and is not of such short duration The studies by Canestrini and Peiper show that the circulatory and respiratory responses to auditory stimuli are likewise of short duration This would seem to indicate no "stirred-up" state of the viscera

5. Gross activity of a period is increased when the number of stimuli are increased, but not proportionally because with decrease in the interval between stimuli they become *on the average* individually less effective

6 Somehow the newborn child is enabled to adjust to situations of this kind by a process which involves a reduction in the magnitude and extent of its responses to recurring stimuli

References

1 BERSOT, H Développement réactionnel et réflexe plantaire du bebé né avant terme à celui de deux ans. *Schweiz Arch f. Neur u. Psychiat*, 1920, **7**, 212-231; 1921, **8**, 47-71

2. CANESTRINI, S. Über das Sinnesleben des Neugeborenen (*Monog a d. Gesamtgeb d Neur u Psychiat*, No 5) Berlin Springer, 1913 Pp 104.

3 GATEWOOD, M C, & WEISS, A. P. Race and sex differences in newborn infants *J. Genet Psychol.*, 1930, **38**, 31-49

4 HALLER, M W The reactions of infants to changes in the intensity and pitch of pure tone *J Genet Psychol.*, 1932, **40**, 162-180

5 IRWIN, O C The amount and nature of activities of newborn infants under constant external stimulating conditions during the first ten days of life *Genet Psychol Monog*, 1930, **8**, 7-92

6. IRWIN, O C, WEISS, A P A note on mass activity in newborn infants *J Genet Psychol*, 1930, **38**, 20-30

7 LOWENFELD, B. Systematisches Studium der Reaktionen der Sauglinge auf Klange und Gerausche *Zsch f Psychol.*, 1927, **104**, 62-96

8. MINKOWSKI, M. Ueber fruhzeitige Bewegungen, Reflexe und muskulare Reaktionen beim menschlichen Foetus, und ihre Beziehungen zum foetalen Nerven- und Muskelsystem *Schweiz med Woch*, 1922, **52**, 721-724, 751-755

9. PEIPER, A Sinnesempfindungen des Kindes vor seiner Geburt. *Monatssch f. Kinderhk*, 1924, **29**, 236-241

10 ———— Untersuchungen uber die Reaktionzeit im Sauglingsalter. I Reaktionzeit auf Schallreiz *Monatssch f. Kinderhk*, 1925, **31**, 491-506.

11 ————. Die Hirntatigkeit des Neugeborenen *Jahrb f Kinderhk*, 1925, **111**, 290-314

12 PRATT, K C. Note on the relation of temperature and humidity to the activity of young infants. *J Genet. Psychol*, 1930, **38**, 480-484

13 ———— A note upon the relation of activity to sex and race in young infants *J Soc Psychol*, 1932, **3**, 118-120

14 ———— The neonate In *A handbook of child psychology*, 2nd ed, rev, ed by C Murchison Worcester, Mass. Clark Univ Press, London Oxford Univ Press, 1933 Pp 163-208

15. PRATT, K C., NELSON, A K, & SUN, K H The behavior of the newborn infant *Ohio State Univ Stud Contrib Psychol*, 1930, No 10 Pp ix+237.

16 SACHS, R Beobachtungen uber das physiologische Verhalten des Gehororgans Neugeborener *Arch f Ohrenhk*, 1893, 35, 28-38

17 WATSON, J B Psychology from the standpoint of a behaviorist. Philadelphia Lippincott, 1919 Pp. ix+429

18. WOODWORTH, R S. Psychology New York: Holt, 1929 Pp 590

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LES EFFETS D'UNE STIMULATION AUDITIVE RÉPÉTÉE SUR L'ACTIVITÉ GÉNÉRALE DES NOUVEAU-NÉS

(Résumé)

L'auteur a étudié les effets des stimuli auditifs répetés sur l'activité générale des nouveau-nés On a mesuré les reactions de vingt-huit enfants entre les âges de 2 à 11 jours au moyen d'un appareil spécial de stabilimètre-polygraphe lequel a enregistré graphiquement les mouvements du corps

On a comparé l'activité des périodes de contrôle et celle des périodes expérimentales pendant lesquelles des stimuli auditifs d'une intensité constante ont été présentés d'une manière automatique toutes les 10, 30 ou 60 secondes

Les résultats de l'étude montrent que l'activité brute totale s'accroît pendant les périodes où l'on fait subir des stimuli auditifs à un bébé. L'activité augmentée est le résultat des réponses immediates aux stimuli individuels plutôt que celui d'une plus grande irritabilité ou inquiétude La forme des réponses évidentes ne conforme pas aux spécifications ordinaires du terme *émotion*

Quand on augmente le nombre de stimuli auditifs pour chaque durés, l'activité brute d'une période s'accroît mais non proportionnellement parce que les stimuli deviennent en moyenne individuellement moins efficaces avec un accroissement de l'intervalle entre eux Ainsi le nouveau-né peut s'adapter à cette sorte de situation du milieu par un processus où il s'agit d'une réduction de la grandeur et de l'étendue de ses réponses aux stimuli répétés

PRATT

DIE WIRKUNG WIEDERHOLTER GEHÖRSREIZE AUF DIE ALLGEMEINE TATIGKEIT NEUGEBORENER KINDER

(Referat)

Der Autor untersuchte die Wirkung wiederholter Gehorsreize auf die allgemeine Tatigkeit neugeborener Kinder Die Reaktionen von 28 Kindern im Alter von 2-11 Tagen wurden vermittelst besonderer Stabilimeterpolygrapheneinheit gemessen, die die Korperbewegungen graphisch aufzeichnete

Die Tatigkeit wahrend der Kontrollperioden wurde mit der Tatigkeit wahrend der Experimentalperioden verglichen, wahrend welcher Gehorsreize konstanter Starke automatische jede 10, 30, oder 60 Sekunde gegeben wurden

Die Ergebnisse der Untersuchung zeigen, dass die Gesamttatigkeit

während der Perioden, während welcher ein Baby Gehörsreizen ausgesetzt ist, vermehrt wird. Die vermehrte Tätigkeit ist eher die Wirkung der unmittelbaren Reaktionen auf einzelne Reize als eine erhöhte allgemeine Erregbarkeit oder Ruhelosigkeit. Der Typus der offenkundigen Reaktionen stimmt nicht überein mit der üblichen Beschreibung des Begriffes *Gefühl*.

Wenn die Zahl der Gehörsreize pro Zeiteinheit erhöht wird, so nimmt auch die Gesamttätigkeit einer Periode zu, aber nicht proportional, weil sie mit der Abnahme des Intervals zwischen den Reizen einzeln Durchschnittlich weniger wirksam werden. Dadurch kann sich das neugeborene Kind den umgebenden Situationen dieser Art anpassen, durch einen Vorgang, der eine Verminderung der Grosse und der Ausdehnung der Reaktionen auf wiederkehrende Reize in sich schliesst.

PRATT

THE EFFECTS OF REPEATED VISUAL STIMULATION UPON THE ACTIVITY OF NEWBORN INFANTS*[1]

From the Department of Psychology of Ohio State University

KARL C PRATT

INTRODUCTION

The variety and invariable occurrence of certain responses to visual stimuli are indubitable evidence of the sensitivity of the visual equipment of the neonate Whether mechanisms are available for differential responses to the stimulus variables (wave-length, wave-amplitude, and wave-composition) has not been established experimentally, although certain of the reflexes elicited manifest a relation between the magnitude, or even the occurrence, of the response and the intensity of the stimulus This has been established by Pratt, Nelson, and Sun (9) for the oculopalpebral reflexes, and by Peiper (6) for the eye-neck (*Augenreflex auf den Hals*) reflex. Utilizing the latter response, Peiper (7) has been able to show that even in premature infants the Purkinje shift appears upon dark-adaptation. It is claimed that totally color-blind individuals do not have the Purkinje phenomenon and that its presence in normal newborn infants indicates, to that extent, the functioning of the cones at this stage of development

The most invariable responses elicited by visual stimulation are the palpebral reflexes, since these occur whether the eyes are closed or not Pupillary reflexes are of a similar high order of frequency.

If the visual stimulus is of proper size and intensity and if it is moved at a slow rate of speed, a newborn infant, if awake, will frequently pursue the moving spot of light by head- and eye-following movements. McGinnis (3) would deny the possibility of genuine visual pursuit during the early part of the neonatal period. The

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[1]This investigation was completed while the writer was National Research Council Fellow at Ohio State University during 1930-31 Acknowledgment of obligations is hereby accorded to the Council, the late Dr A, P Weiss, who acted as director, the various cooperating departments at Ohio State University, and Mr Charles Hu for his services as assistant

writer believes, however, that McGinnis studied too small a number of cases (4) to warrant such a generalization.

In addition to these reactions, strabismic and nystagmic movements occur. Optic nystagmus has been studied with an excellent technique by McGinnis.

Both Canestrini (2) and Peiper (4) have demonstrated the effects of visual stimulation upon circulation and respiration. The former likens the circulatory and respiratory responses produced in the newborn child by intense visual stimuli to similar responses which may be observed when adults are frightened The latter (5) notes that intense visual stimuli evoke the "fear" (*Schreck*) reaction—a pattern of responses similar, except for refractory phase, to the Moro reflex

Pratt, Nelson, and Sun's (9) quantitative measurements of bodily activity to visual stimulation show that the reactions are more pronounced at birth, and that they decline thereafter during the first two weeks of life. This would seem to indicate that the "fear"[2] or "Moro" component drops out rapidly with age.

The effects of continuous visual stimulation of different intensities are unknown for this period of life And beyond the relatively quick extinguishing of the "Schreck" reaction, noted by Peiper in cases when stimuli are repeated, no quantitative measurements of the effects of repeated stimulation appear to have been reported in the literature.

The Problem

The aims of this investigation were.

1 To obtain a quantitative measurement of the effects of repeated visual stimuli upon the activity of newborn infants.

2 To determine whether the effects, if any, are due to immediate reflex responses or to a general heightening of activity during the period of stimulation.

3 To discover the relation between activity and the number of stimuli per unit time

4. To study the changes in activity with successive repetitions of the stimulus.

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[2]As indicated in a paper on the effects of repeated auditory stimulation upon activity, this term is valueless if it is to carry the connotation of "emotion" or "emotional state." The activities are of quick reflex duration, and to avoid ambiguity it seems best to extend the term "Moro" to the complex, regardless of the modality of the arousing stimulus

Apparatus

The control and recording apparatus consisted of a movable experimental chamber with built-in stabilimeter and polygraph unit.[3]

As in the study upon the effects of repeated auditory stimulation, an interval-timer unit operated by the polygraph motor made it possible to present visual stimuli automatically from a 75-watt "daylight bulb" (the receptacle being mounted on the ceiling of the experimental cabinet directly over the infant) with a duration of 1 second and at intervals of 10, 30, or 60 seconds according to the experimental schedule. The infants were under a constant illumination of low luminosity value approaching deep twilight conditions (9).

Technique

The procedure employed in this research was essentially the same as in the study of the effects of auditory stimulation Infants were selected on the basis of nursery conditions Previous study (9) had shown the occurrence of palpebral reflexes and the Moro complex even when the infant's eyes were closed, so it was not considered necessary to limit the study to those infants that were awake

The period of experimentation was divided into three parts' (1) an initial adaptation period of 2 minutes, during which an opportunity was provided for the stimulating effects of manipulation of the infant to subside, (2) a control period (CP), in which activity was recorded during a 10-minute period with no specific stimulations, (3) an experimental period proper (EP), during which the activity of a 10-minute period of stimulation at determined intervals was recorded The order of (2) and (3) was varied so as to avoid errors due to the progressively changing state of the organism from one feeding period to the next

Results

This investigation was conducted concurrently with that upon the effects of auditory stimulation and hence deals with essentially the same group of infants As Table 1 shows, the number of experiments completed under the condition "awake" is very limited This indicates merely that general activity is usually very great

[3]For complete details of this apparatus and method of operation other publications (8, 9) may be consulted

when the infant is awake McGinnis (3), as well as many other investigators, has noted this It has been demonstrated (9), however, that visual stimuli have certain effects, even when the eyes are closed. Palpebral reflexes almost invariably appear and in many instances the Moro complex or some element thereof. The latter is most pronounced during the first 36 to 48 hours and declines thereafter It is therefore obvious that a function changing with age would necessitate segregation according to age periods Our selection avoids this by eliminating the short period of maximum sensitivity as measured by the Moro complex, just as our age selection in the auditory experiment ruled out the period of relative auditory insensitivity. When the research program was initiated it was thought that the major effects of repeated auditory and visual stimulation might consist of heightened general activity as well as immediate specific responses occurring throughout the period during which the stimuli were applied. The age selection therefore oper-

TABLE 1

NUMBER AND DISTRIBUTION OF INFANTS ACCORDING TO SEX, RACE, AND AGE, NUMBER AND TYPES OF EXPERIMENTS

	No	28
A	Age	Range 2-11 days, Av 6 days
	Sex	Males 12, females 16,
	Race	Whites 5, Negroes 22, Chinese 1
B	Complete	68
	Not complete	25 (asleep 1, awake 24)
C	*Dry* and *asleep*	38
	Wet or *awake*	30
	Asleep	58
	Awake	10
D	10 seconds	24
	30 seconds	18
	60 seconds	26

Legend

A, number and distribution of infants
B, number of visual experiments
C, distribution of experiments according to nursery or physiological conditions
D, distribution of experiments according to interval of stimulation
Complete, experiments in which both control and experimental periods were completed
Not completed, experiments in which either control or experimental periods were unfinished

ated to provide a group in which there were no significant changes in activity correlated with age differences.

As in the auditory studies, no attempt was made to secure norms of activity, since the problem dealt with the relative activity during periods of stimulation as compared with periods of non-stimulation under as similar physiological conditions as it was possible to obtain.

TABLE 2

ACTIVITY PER UNIT TIME IN COMPLETED CONTROL AND EXPERIMENTAL PERIODS, ACCORDING TO PHYSIOLOGICAL OR NURSERY CONDITIONS

		No	Range	S D	Mean	P E	Diff of M's	P E $_{diff}$	Diff / P E $_{diff}$
A	CP	68	0-27 40	6 50	6.12	0 53	0 18	0 80	0 22
	EP	68	0-33 20	7 34	6 30	0 60			
B	CP	38	0-21 50	4 48	3 86	0 49	0 32	0 67	0.47
	EP	38	0-18 10	4 28	3 54	0.46			
C	CP	30	0-27 40	7 46	9 00	0 91	0 80	1 40	0.57
	EP	30	0-33 20	8 74	9 80	1.07			
D	CP_d	42	0-21.50	5 06	4 16	0 52	5 14	1 09	4.71
	CP_w	26	0-27 40	7 28	9 30	0 96			
E	CP	10	0-27 40	10 30	12.40	2.19	2 40	2 92	0 82
	EP	10	0-28 20	9 12	10 00	1 94			

Legend:

No, number of experiments

Range, stabilimeter oscillations per minute

CP (control period), 10-minute period during which no stimuli were given

EP (experimental period proper), 10-minute period during which visual stimuli were given

A, activity per unit time in all complete control and experimental periods

B, activity per unit time under the conditions *dry* and *asleep*

C, activity per unit time under the conditions *wet* or *awake*

D, activity per unit time in control periods according to nursery conditions *dry* or *wet* (*d* or *w*)

E, activity per unit time under the condition *awake* (this is introduced to complete the record and not because it can have any significance in view of the number of cases)

Hence the values secured in experimental periods have significance only when viewed in relation to the values for their corresponding control periods.

The measure of activity selected has been the number of stabilimeter oscillations per unit time, since this measure is easily obtained and has been found satisfactory for problems of this kind.

Table 1 shows that.

1 The selection of infants is predominantly Negro

2. In practically all of the experiments which were not completed the infants were awake.

3 In the experiments which were completed the infants were awake in but 10 cases out of 68

Table 2 shows that:

1. In all periods which were completed there was no significant difference in activity between control and experimental periods. The mean of EP is 6 30; of CP, 6 12, with the difference of the means/P E of the difference being 0 22

2 Similarly, there was no significant difference between control and experimental periods according to the physiological and nursery conditions studied

3 Activity is doubled under the condition *wet*, as compared with *dry* The mean of CP (wet) is 9 30, of CP (dry), 4.16, with the difference of the means/P.E. of the difference equal to 4.71

TABLE 3

COMPARISON OF ACTIVITY PER UNIT TIME IN COMPLETED EXPERIMENTAL PERIODS ACCORDING TO INTERVAL OF VISUAL STIMULATION

	Interval	Mean	Diff. of M's	PE_{diff}	$\frac{\text{Diff}}{PE_{diff}}$
EP	10 sec	7 10	2 76	1 18	2 33
	30 sec.	4 34			
EP	30 sec.	4.34	2.60	1 30	2 00
	60 sec	6.94			
EP	10 sec	7 10	0 16	1 53	0 10
	60 sec	6 94			

Table 3 shows that:

1. There is no significant difference in activity when stimuli are presented every ten seconds as compared with the activity when stimuli are presented every 60 seconds. The mean of the 10-second interval is 7 10, of the 60-second interval, 6.94, with the difference of the means/P E. of the difference equal to 0 10.

2. The lower mean (4 34) of the 30-second interval has no significant relation to the number or spacing of stimuli, but arises from the fact that two-thirds of these cases were *dry* whereas in the other intervals only about one-half were in this condition This interpretation is supported by D (the mean of the *dry* group) in Table 2.

Discussion

For vision, as for auditory sensitivity, additional studies are needed of the effect of different intensities of the stimuli The results in Tables 2 and 3 show that in this experiment no significant changes in measurable activity, either of a general or specific character, were produced by visual stimuli. This was true in spite of the fact that the palpebral reflexes, which are almost invariably present, give evidence of visual sensitivity, and that visual stimuli of far less intensity may release almost the same pattern of responses as do auditory stimuli during the first two days after birth The initial presence of this pattern of response would seem to indicate that the startled jerk brought, in the older individual, by an intense visual stimulus of sudden occurrence does not necessarily mean that it has been conditioned by some such process as lightning (conditioned) followed by thunder (unconditioned) eliciting the reaction in question. As Bersot (1) has noted, many a response which disappears in the normal course of development may be caused to reappear by increasing the intensity of the stimulus

The posture of the child on the stabilimeter and the limitation to bi-dimensional recording made it impossible to measure Peiper's "neck reflex." With his apparatus and with this reflex as index, the effects of repeated visual stimuli might be studied quantitatively Under the usual conditions of neonatal existence, visual stimuli seem to elicit more limited or localized responses than do the auditory, or perhaps we should say the responses to visual stimuli rarely involve the trunk musculature or that of the extremities, whereas with auditory stimulation these are conspicuously involved.

Conclusions

1. Repeated visual stimuli of the intensity and duration employed in this research do not appreciably increase the activity of the period during which they occur. This means that neither the general activity of the period is heightened nor are there many specific responses of the gross musculature of the body

2 There is no evidence of a genuinely significant difference in activity according to the number of stimuli presented per unit time. The lower activity in the experimental period in which there was an interval of 30 seconds between stimuli was due to a relatively higher percentage of cases that were asleep and dry

3 There is some slight evidence, provided by the polygraph records and the experimenter's protocols, of a specific response of the Moro type to the first one or two stimuli, but the number of oscillations in this connection was too small to affect the results appreciably.

4 The fact that a much weaker visual stimulus does arouse the "fear" or "Moro" pattern of responses during the first two days would seem to indicate that the later "startled reaction" of the older individual to an intense flash of light may not be a learned response, conditioned through auditory stimulation. On the contrary, this may be merely another instance of a reaction which is no longer elicited by moderate intensities of stimuli but which reappears when the intensity is greatly increased.

References

1 Bersot, H Développement réactionnel et reflexe plantaire du bébé né avant terme à celui de deux ans. *Schweiz Arch f. Neur u. Psychiat*, 1920, 7, 212-231, 1921, 8, 47-74

2 Canestrini, S Über das Sinnesleben des Neugeborenen (*Monog. a d. Gesamtgeb. d. Neur u Psychiat*, No 5) Berlin Springer, 1913 Pp 104

3 McGinnis, J M Eye-movements and optic nystagmus in early infancy *Genet Psychol Monog*, 1930, 8, 321-427

4. Peiper, A Beitrage zur Sinnesphysiologie der Fruhgeburt. *Jahrb f Kinderhk*, 1924, 104, 195-200

5. ———. Die Hirntatigkeit des Neugeborenen *Jahrb f Kinderhk.*, 1925, 111, 290-314

6 ——— Über einen Augenreflex auf den Hals im fruhen Sauglingsalter *Jahrb. f Kinderhk*, 1926, 113, 87-89.

7 ———. Über die Helligkeits und Farbenempfindungen der Fruhgeburten *Arch f Kinderhk*, 1926, 80, 1-20

8 PRATT, K C The effects of repeated auditory stimulation upon the general activity of newborn infants. *J Genet Psychol*, 1934, **44**, 96-116

9 PRATT, K C., NELSON, A K, & SUN, K. H The behavior of the newborn infant *Ohio State Univ Stud Contrib Psychol*, 1930, No 10 Pp ix+237.

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LES EFFETS D'UNE STIMULATION VISUELLE RÉPÉTÉE SUR L'ACTIVITÉ DES NOUVEAU-NÉS

(Résume)

L'auteur a étudié les effets des stimuli visuels répétés sur l'activité générale des nouveau-nés. On a mesuré les réactions de vingt-huit enfants entre les âges de 2 à 11 jours au moyen d'un appareil special de stabilimètre-polygraphe lequel a enregistré graphiquement les mouvements du corps

On a comparé l'activite des périodes de contrôle et celle des périodes expérimentales pendant lesquelles des stimuli visuels constants ont été présentes d'une manière automatique pendant une durée d'une seconde toutes les 10, 30 ou 60 secondes

Les résultats de cette étude montrent que les stimuli visuels de cette intensité et de cette durée n'accroissent pas l'activité brute totale des périodes où ils se montrent Ainsi à cet âge il n'y a aucun accroissement de l'inquiétude générale et il n'y a pas beaucoup de réponses spécifiques de la musculature entière du corps Cela s'applique à toutes les vitesses de l'application des stimuli étudiés

La décharge de la forme "Moro" de reponses par des stimuli visuels de moins d'intensité même pendant les deux premiers jours de l'existence postnatale avec l'affaiblissement et la disparition rapides subséquents des réponses de la musculature entière fait un vif contraste avec la manière dont se développent les réponses aux stimuli auditifs

PRATT

DIE WIRKUNG WIEDERHOLTER GESICHTSREIZE AUF DIE TATIGKEIT NEUGEBORENER KINDER

(Referat)

Der Autor untersuchte die Wirkung wiederholter Gesichtsreize auf die allgemeine Tatigkeit neugeborener Kinder Die Reaktionen von 28 Kindern im Alter von 2-11 Tagen wurden vermittelst einer besonderen Stabilimeter-polygrapheneinheit gemessen, die Korperbewegungen graphisch aufzeichnet

Die Tatigkeit wahrend der Kontrollperioden wurde mit der Tatigkeit wahrend der Experimentalperioden verglichen, wahrend welcher konstante Gesichtsreize von der Dauer einer Sekunde automatisch im Abstand von 10, 30, 60 Sekunden gegeben wurden

Das Ergebnis der Untersuchung zeigt, dass Gesichtsreize der hier gegebenen Starke und Dauer die Gesamttatigkeit der Perioden, wahrend welcher sie dargeboten werden, nicht vermehren. Daraus folgt, dass auf dieser Altersstufe eine Zunahme in der allgemeinen Unruhe nicht stattfindet, ferner lasst sich festellen, dass es nicht viele spezifische Reaktionen der rohen Muskulatur des Korpers gibt. Dies trifft auf alle Verhaltnisse der Reizanwendungen zu, die untersucht wurden.

Der Ablauf des "Moro"-typus der Reaktionen durch Gesichtsreize geringerer Starke wahrend der ersten zwei Tage nach der Geburt mit nachfolgender schneller Abnahme und Verschwinden der Reaktionen der rohen Muskulatur steht im auffalligem Gegensatz zum Verlauf der Entwicklung von Reaktionen auf Gehorsreize.

PRATT

AN EXPERIMENTAL STUDY OF CHILDREN'S BEHAVIOR IN A SPATIAL COMPLEX*

From the Institute of Child Welfare, University of California

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The experiment here reported deals with the reactions of children in a body maze, with particular reference to the development of an "intelligent" response to two pathways leading to the same exit. The general pattern of the maze is similar to that which has been used by Hsiao (2), and by Tolman and Honzik (4), in the study of "insightful" behavior in rats It consists (see Figure 1) essentially of three pathways of unequal length, paths 1 and 2 lead through doors D_1 and D_2 into a common corridor and to a common exit door C, path 3 leads, by a roundabout route, to a separate exit door D_3. The essential problem can be briefly stated as follows, after a child has become acquainted with all of the routes in the maze, how will he behave when he approaches the common door C through path 1, and finds it locked? Will he return to the entrance through 1, and then go directly to 3, or will he again approach the locked common door through path 2?

The latter behavior may be taken as an indication of a failure to grasp the field relationships of the maze In terms of adult standards, it appears as "stupid" and "insightless" With reference to the learning process utilized by the child, it would suggest learning based on trial and error or on specific conditionings, rather than on insight, configurational or structured responses, or response to parts in the light of the whole If, on the other hand, the child does actually make the correct choice at the choice points, this would be capable of interpretation either in terms of (*a*) chance, (*b*) "irradiation" of an avoiding response, or (*c*) insight If correct choices are frequently or generally made on the initial test trial, it would then become desirable to complicate the pattern of the maze in order to

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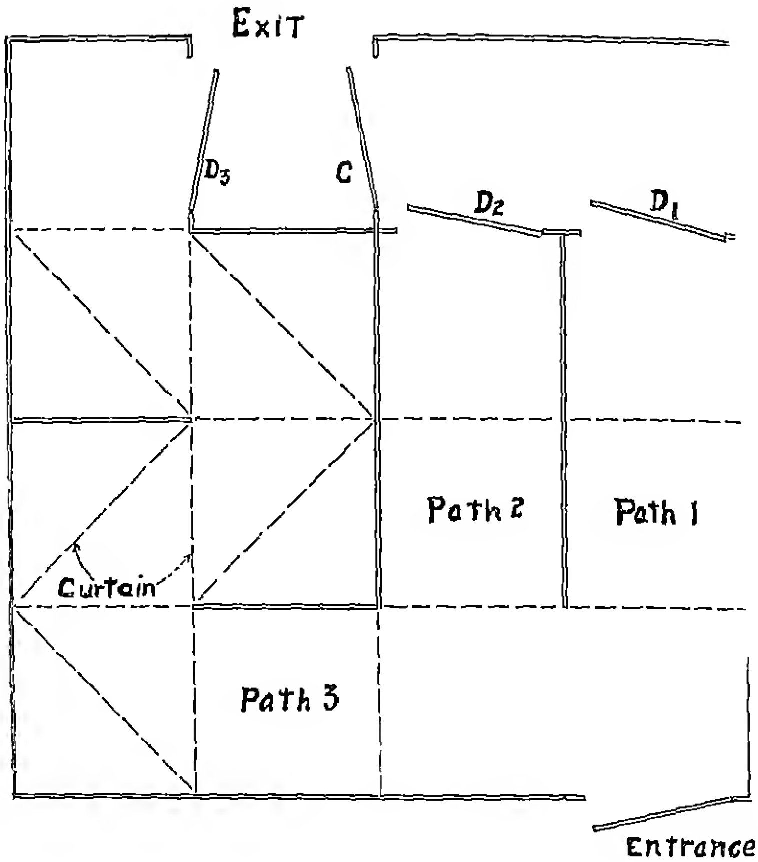

FIGURE 1
The Maze Patterns

rule out the first two factors. The present pattern, however, has been chosen as the simplest possible one for testing the reaction to a common path.

An earlier paper (1) has described the construction of the maze, and the method by which the doors can be electrically controlled from an elevated observation booth. Two experimenters are required to operate the maze and take necessary records E_1 stands in the elevated balcony, viewing the child through a screen. His duties

are to (1) control the doors, (2) record specific features of the behavior of the child in each part of the maze (e.g., jumping, running, hesitating, pushing at walls, etc.), (3) record the path and explorations taken by the child, (4) record the time from the moment a child enters until he comes out at the exit, (5) determine the experimental procedure relative to the experimental stage, and (6) give buzzer signals to E_2 concerning desired experimental procedure The duties of E_2 are to bring the child to the maze, show him the entrance and exit doors (from the outside of the maze), and at the appropriate signal to start the child in the maze, urging him, "Now find the way to the other door as quickly as you can." In early trials, in a few cases, it has proved necessary to give verbal encouragement, if a child became emotionally disturbed Observational records of cooperativeness, interest in the maze, verbalizations, and relevant behavior signs were taken by both observers, and particularly by E_2 A detailed behavior rating scale was also filled in by E_2, the results from which are not here reported. A high level of motivation prevailed among the children. The only external rewards used were jack-stones and marbles, which were shown to the child before the first trial of the day, and were given to him following the last run of the day After each run the child received verbal praise from E_2. Motivation was strengthened by the children's attitude of competition "to be taken first"; the nature of the task, involving full bodily activity rather than the more restricted behavior of ordinary laboratory procedures, was well suited to maintaining interest.

Six separate experiments were conducted, and records taken for over 3000 runs The procedures in the training series were as follows

Experiment I 21 nursery-school children, ages 30 to 51 months, mean CA 42 months. The mental age range was from 27 to 79 months In this, as in all the other younger groups, the average IQ was between 115 and 120, the intellectual and social selection was similar to that found in representative private schools. In Experiment I the procedure involved (*a*) free choice trials, in which the children were given four runs a day for three days, any path being permitted, (*b*) restricted trials, requiring children to extend their practice in the various pathways This last was especially necessary in cases in which a strong tendency had developed to prefer one path to the exclusion of the others. The restriction was

accomplished by locking doors 1, 2, and 3, as needed; door *C* was never locked. In these trials the child was required to take the paths in rotation Thus, if a child took path 1 in his first run on a given day, path 2 was the only one open for the second run, and path 3 for the third run. Altogether, each child received approximately 12 free trials and 18 restricted trials.

Experiment II· The same group was used as in the preceding experiment, after an interval of three weeks Approximately 9 free choice and 11 restricted preliminary runs were given per child

Experiment III: 57 nursery-school, kindergarten, and elementary-school children Ages 32 to 94 months, mean CA 59 months An average of 9 free choice and 7 restricted preliminary runs were given. Instead of being spread over a week or more, however, these trials were all given on one day. Experiment III was given approximately 5 months after Experiment II, and included 13 of the same subjects

Experiment IV: 28 kindergarten and elementary-school children. Ages 51 to 94 months, mean CA 71 months. In this experiment no restriction occurred through locking of the doors 1, 2, or 3. If, however, the child became fixated on a single pathway, E_2 would suggest to him, "This time try a different way" An average of 19 preliminary runs was made, per child The common door *C* was propped open during the preliminary training Experiment IV was given about three weeks after Experiment III, and included 9 of the same subjects

Experiment V: 18 kindergarten and elementary-school children, ages 51 to 94 months, mean CA 72 months. There was considerable overlapping as to subjects in Experiments III, IV, and V. In Experiment V the maze pattern was changed somewhat in order to accentuate the directional difference at the choice point between paths 2 and 3. These were no longer at right angles to each other, but led in opposite directions. The common door, as in Experiment IV, was propped open in the preliminary series Experiment V was given a week after Experiment IV, and included 10 of the same subjects. The training period included an average of 22 trials

Experiment VI. 20 children, of the fifth and sixth grades, were tested with the maze patterns used in Experiments I, II, and III. Ages 115 to 143 months, mean CA 133 months. An average of 2 restricted and 9 free choice preliminary trials were given, all on

the same day This experiment was conducted by Dr H E Jones

Table 1 gives a record of paths attempted and completed, for each experiment.

TABLE 1

ATTEMPTED AND COMPLETED RUNS IN THE TRAINING PERIOD

	Total times path entered (1st choice) Path			Number of runs completed Path		
	1	2	3	1	2	3
Experiment I	259	223	111	241	227	125
Experiment II	201	138	75	209	103	102
Experiment III	437	309	165	431	271	209
Experiment IV	199	189	150	199	176	163
Experiment V	142	136	112	139	133	118
Experiment VI	80	74	57	66	75	70

It may be noted that in each experiment a definite preference existed for path 1, and that path 3 (longest, and involving more intervening curtains, and with more blind alleys) was least preferred. These differences in preference were subject to interference from the restricted runs, which equalized practice somewhat. The purpose of the training series was not to make the runs in path 3 equal to those in the other pathways, but merely to make sure that every child had a thorough acquaintance with the maze, derived from repeated experience in each path. It was desirable that at the end of the training series a greater preference should remain for paths 1 and 2 than for 3.

The test series, or series of critical runs, were similar in all experiments Doors 1, 2, and 3 were unlocked, but door *C* was locked for the first time in the child's experience. It remained continuously locked throughout the test series In Table 2, results for six experiments, and for five or more test runs, are presented in terms of three patterns of runs. In the first pattern (x-x-3), the child returns a second time to the locked door, through another path; the succession of runs may be 1-2-3, or 2-1-3, or even 1-2-1-3 In the second pattern (x-3), the child goes to the locked door through either 1 or 2, but thereafter runs directly to path 3. In the third pattern the child runs to 3 without attempting 1 or 2. In the first critical run, no examples occur of this last, since the critical series is never started except when the child is in path 1. A positive run on the first criti-

TABLE 2

PERCENTAGES OF CHILDREN MAKING RUNS OF A GIVEN PATTERN

Test runs	Experiment →	I			II			III			IV			V			VI		
	Pattern →	x-x 3	x-3	3	x-x 3	x-3	3	x-x-3	x-3	3	x-x 3	x-3	3	x-x 3	x-3	3	x-x 3	x-3	3
1		62	38		81	19		61	39		29	71		28	72		50	50	
2		19	38	43	38	34	29	23	42	45	33	32	36	34	39	28	30	40	30
3		10	20	71	43	29	29	10	41	50	22	53	25	17	67	17	20	45	35
4		10	10	81	43	19	38	4	39	57	7	36	57	0	39	61	5	43	53
5		5	15	80	29	24	48	6	30	63	0	50	50	0	66	33	7	40	53
6		0	9	91	26	33	42	4	32	64	0	40	60						
7					0	32	69	0	35	64									

TABLE 3

PERCENTAGES OF RUNS ACCORDING TO THREE PATTERNS, AND CLASSIFIED BY SEX, CA, AND MA

Test runs		Sex						CA						MA					
		Boys			Girls			Older			Younger			Higher			Lower		
	Pattern →	x-x-3	x-3	3	x x 3	x-3	3	x-x-3	x 3	3	x x 3	x-3	3	x-x-3	x-3	3	x-x 3	x 3	3
1		56	44		52	48		63	38		45	55		65	35		45	55	
2		16	45	38	30	32	38	34	36	30	17	42	41	33	27	40	21	45	34
3		22	44	35	16	40	44	20	43	38	17	44	39	22	32	46	18	46	35
4		18	29	53	6	31	62	11	21	67	10	41	49	13	13	75	13	44	44
5		8	36	57	7	37	56	6	36	59	8	38	55	6	34	60	9	37	54
6		11	24	65	6	34	60	8	27	65	9	31	60	8	22	70	10	38	51
7		5	16	79	6	29	65	5	26	68	0	24	76	5	21	75	6	22	[illegible]

cal trial is defined as one in which the child, approaching the locked door through path 1, returns to the entrance, rejects path 2, and goes directly to path 3. It is, of course, recognized that a certain proportion of positive runs may occur through chance. This proportion is, however, smaller than 50%, because a preference for path 2 over 3 has been developed in the training series, and also because in all experiments except Experiment V the child must pass the entrance to path 2 before entering 3.

Table 2 indicates the following:

1. In Experiments I, II, and III the majority of the children make "failures" in the first test run—returning to the locked common door through a second path.

2. An increased avoidance of paths 1 and 2, leading to the common path, is shown on subsequent runs Subjects who received 10 or more test runs (not shown in the table) usually went directly to path 3 and made no further attempts to enter the common path.

3. A repetition of the experiment with the nursery-school children showed an *increased* number of initial failures and a slower elimination of failures in successive trials (Experiment II as compared with Experiment I).

4. With the group of greater average age, in Experiment III (59 months as compared with 42 months), no increased efficiency is shown, the comparison, however, is slightly unfair to these older children, since their training series was condensed to trials on a single day

5. In Experiments IV and V there is some hint of a greater understanding of the problem This is supported also by a greater amount of secondary evidence (verbalization, hesitation at the choice point, followed sometimes by a sudden rush into path 3). Even in these experiments, however, over one-fourth of the children make failures in the first critical test run.

6 Experiment VI, with older children (mean age 133 months), is comparable in procedure to Experiment III. The older subjects are not markedly superior to the younger children in the percentage of initial positive runs

7. In the test runs subsequent to the first critical test, five additional trials are in nearly all cases sufficient to eliminate runs of the pattern x-x-3 In Experiment I, runs of the pattern x-3 were also eliminated rapidly

Table 3 gives a comparison of boys and girls and also a comparison between the upper and lower halves of each group when divided on the basis of CA and of MA. With respect to these comparisons, results were reasonably consistent in the several experiments, and the data were therefore combined. Experiment VI, with children whose ages fall beyond the range of the others, was not included.

Table 3 indicates the following

1. There are no significant sex differences in the initial test runs, or in the subsequent elimination of runs to the common path

2. Younger children perform better than older children, particularly in the first test run (This is a consistent finding, in each of the five experiments)

3 Children lower in MA perform better than children higher in MA. (This is also a consistent finding)

Discussion

1. The problem presented was that of reacting to a common path and common door. Evidence of such reaction, on the first critical test run, might consist of (*a*) verbal report, (*b*) drawings of the maze (by the older children), (*c*) hesitation at the choice point, followed by a dash into the only path still open, or (*d*) correct choice of the open path. The latter criterion is not in the individual case conclusive evidence, for a child might take the open path by chance, or by a generalizing of a conditioned avoidance to path 1, without any specific representation of the common "bad" features of paths 1 and 2 We have seen that in Experiments I, II, and III only a minority of the children made correct or positive choices (x-3) on the first critical runs, and this number of positive choices could have been achieved by chance. The behavior observed in these experiments suggests that the children tended to react to the pathways as separate units, and, in general, without a grasp of the total pattern or of the field relationships of this quite simple organization of paths. The evidence is negative with reference to the emergence of "inferential expectation" (3) It does not appear that the maze is, in most cases, comprehended as a meaningful whole or configuration, the indication is, rather, that its component parts elicit reactions of a "piecemeal" character

2. It is possible (although we have no direct evidence for it) that a return to the locked common door through another path, in the

first critical trial, may at times be dependent upon factors other than haphazard or piecemeal reaction In all previous runs, during the training series, the common door has been unlocked When the child approaches it through path 1 and finds it locked, he may formulate an hypothesis that it will be unlocked if he approaches it from another direction When the child approaches the locked common door through path 1, in the first critical trial, he experiences a frustration which may in some cases lead to a simple avoidance reaction, but which in other cases may conceivably involve taking path 2. Taking path 2 instead of path 3, therefore, would not be evidence of lack of insight concerning the common door, but would indicate an exploratory type of insight, at a higher level On the basis of present evidence, the writer is inclined to discount this possibility; the formulation of hypotheses, at these age levels, probably occurs so rarely and so unsystematically that only an extreme over-reaction from the law of parsimony would lead a writer to assume their existence as important factors in maze learning Another more probable factor may perhaps be inferred from Lewin's studies of the effects of interrupting an activity It may be observed that when a child finds a door locked, he usually pulls at it again in a more vigorous manner, sometimes he turns away for a moment and then comes back and tries again Frustration may heighten the stimulus value of the door, so that when he has an opportunity to return to it from another path, he does so, *recognizing* the fact that he is returning to the same door; the stimulus value of the locked door would, then, be greater than that of the open pathway (path 3) We cannot in the present evidence exclude the possibility that such factors may have operated in certain cases These would be cases in which the child acted apparently without insight, while the truer interpretation would be that he had the idea of the common door, but through the operation of conflict factors was unable to use this idea intelligently We cannot assume that the behavior was due to lack of motivation, observational data, time records, and the evidence concerning the decline of x-x-3 runs in successive test trials (Table 2) show that the children were, in general, motivated to find an open exit rather than to linger in the maze The typical behavior at a locked door is strongly indicative of frustration and of incentive to find an exit.

3. The smaller proportion of failures in Experiments IV and

V calls for comment. It is apparent that in the training series verbally imposed restrictions are more advantageous for the subject than the method of restricting runs by temporarily locking intermediate doors. Encountering a locked door is more likely to produce confusion (in the preliminary stages of getting acquainted with the maze) than simply being told, "Now try another path" Even under the more favorable conditions of verbal control by the experimenter, over one-fourth of these children, from four to eight years of age, show an absence of discriminatory behavior in the initial test run.

4. If insight and ideational learning were significant factors in these experiments, we would no doubt expect a superior performance from older, and from more intelligent children. The fact that more intelligent children make more failures than the less intelligent is hardly to be anticipated, but may be explained in terms of fixation. Older, more intelligent children more easily become stereotyped in their maze behavior. As a result of the training series (in which they have chosen path 2 more frequently than path 3), they persist in the choice of path 2 even under changed conditions which make this reaction no longer suitable The younger and less fixated subjects are freer, at the choice point in the maze, to respond either by chance, or, in a few cases, with reference to an explicit recognition of the maze pattern This explanation is consonant with the finding that in the same group of children an extension and repetition of the training series (Experiment III) results in an increase rather than a decrease of failures in the first test run.

5. The increased avoidance of the common path, shown on test runs subsequent to the initial critical run, is similar to results obtained by Hsiao (2) Hsiao considered that this was explainable in terms of insight, whereas the present writer, in agreement with Tolman and Honzik (4) considers that only the first test run was critical for insight In the present experiment, it is the writer's contention that the increasing percentage of positive runs (direct to path 3) is readily interpretable in terms of recency factors, and of the development of specific avoidance to path 1 and to path 2 The data are regarded as compatible with theories of learning by conditioning, or by piecemeal acquisitions in the course of trial and error. The experimental conditions described are regarded as permitting the child to become acquainted with all of the factors which are neces-

sary for insightful behavior, but the behavior observed is only rarely suggestive of insight, ideational response, or of "structured" response. If such phenomena are to be demonstrated in children of these ages, other procedures must be sought than those which are involved in this simple maze situation.

References

1. Davis, F, & Batalla, M A life-size alley maze for children *J Genet. Psychol*, 1932, 41, 235-239
2. Hsiao, H H An experimental study of rat's "insight" within a spatial complex *Univ Calif Publ. Psychol*, 1929, 4, 57-70
3. Tolman, E C Purposive behavior in animals and men New York. Century, 1932 Pp 463
4. Tolman, E. C, & Honzik, C H 'Insight'' in rats *Univ. Calif. Publ Psychol*, 1930, 4, 215-232.

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UNE ÉTUDE EXPÉRIMENTALE DU COMPORTEMENT DES ENFANTS DANS UN COMPLEXE SPATIAL

(Résumé)

On rapporte une série de six expériences, où il s'agit des réactions des enfants dans un labyrinthe de grandeur naturelle On a testé approximativement 100 enfants, âgés de 2-1 2 a 12 ans On a utilisé un labyrinthe à trois routes, dont deux se sont unies dans un dernier sentier commun, pendant que la troisième route s'est terminée, en employant des détours, en une sortie séparée On a projeté les expériences dans le but de tester le développement des reponses "intuitives" à la forme du labyrinthe L'apprentissage s'est montre, mais une analyse de plus de 3000 épreuves indique que les enfants ont tendu à réagir aux sentiers comme unités séparées, et en général sans une compréhension des rapports l'un a l'autre de cette organisation tout simple de sentiers On considère les données comparables aux théories de l'apprentissage par le conditionnement, ou par les acquisitions d'essai-erreur au hasard On considère que les conditions expérimentales employees permettent à l'enfant de connaître tous les facteurs nécessaires au comportement intuitif, mais le comportement observe ne suggère que rarement l'intuition, la reponse idéelle, ou la réponse "construite"

Batalla

EINE EXPERIMENTELLE UNTERSUCHUNG KINDLICHEN VERHALTENS BEI RAUMLICHEM BEGRIFF

(Referat)

Man berrichtet uber sechs Experimente uber die Reaktionen von Kindern in einem lebensgrossen Labyrinth Es wurden ungefahr 100 Kinder im

Alter von 2½ bis 12 Jahren geprüft Man gebrauchte das Dreiwegelabyrinth (three-route maze), zwei Wege führten in einen gemeinsamen Endpfad, wahrenddem der dritte auf einem weitläufigen Weg zu einem Separatausgang führte. Die Experimente wurden geplant, um die Entwicklung der "einsichtigen" Reaktionen auf ein Labyrinth zu prüfen Man konnte ein erlernen nachweisen, aber die Analyse von über 3000 Versuchen zeigt, dass die Kinder die Tendenz haben, auf die Pfade als getrennte Einheiten zu reagieren, und im Allgemeinen die Feldbeziehung dieser recht einfachen Organisation der Pfade nicht verstehen Die Angaben dürfen verglichen werden mit den Theorien über das Erlernen durch Erstellung bedingter Reflexe, oder durch stückweise Aneignung aufs Geratewohl Die gebrauchten experimentellen Bedingungen gestatten dem Kinde wohl mit allen Faktoren bekannt zu werden, die für einsichtiges Verhalten vorausgesetzt werden müssen, aber das beobachtete Verhalten weist selten auf Einsicht, ideele Reaktion, oder "strukturierte" Reaktion hin

BATALLA

A STUDY OF INDIVIDUAL DIFFERENCES IN ASSOCIATIVE CAPACITY*

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I PROBLEM

Many interpretations and criticisms of association theory have been developed, such as Hollingworth's theory of redintegration, Pavlov's conditioned reflex, Watson's idea of original movements, and the configurational theory of Gestalt Certainly it is true that few attempts have been made to study the quantitative aspects of association. The reason for this, no doubt, is that few investigators have cared to make an experimental analysis of association. A survey of the literature bearing on association shows, also, that no investigator has attempted to account for individual differences in associative capacity

The purpose of the present investigation is (1) to make a quantitative study of individual and sex differences in associative capacity, and (2) to determine the structural elements in this capacity.

II MATERIAL AND METHOD

In order to study the structure and individual differences found in associative capacity a very simple associative test was used and administered to elementary classes in psychology at Indiana University

Our analysis involved the use of a test which we called "The Indiana University Test of Associative Capacity." This test consists of many repetitions of different codes which are learned as simple associations Directions for the giving of this test are shown in the sample test which follows·

DIRECTIONS FOR TEST OF ASSOCIATIVE CAPACITY

This is not a test of intelligence, it is a test of your ability to make simple associations of the sort you made when you learned the multiplication table

*Recommended by G S Snoddy, accepted for publication by Carl Murchison of the Editorial Board, and received in the Editorial Office, February 21, 1933

On the sheets underneath you will see at the top of the page one line of numbers and one line of letters Each letter is below a number and represents the number above it. Below the two lines at the top of the page are two columns of numbers. At the right of each number, space is left for you to write the proper letters.

Here is a sample

5	9	4	3	7	6
b	*e*	*t*	*c*	*o*	*a*

49,635	*t*	*e*	*a*	*c*	*b*	Note that the letters correspond to the numbers
63,495	*a*	*c*	*t*	*e*	*b*	The first letter corresponds to the first digit, etc
53,697						Fill out the letters in the blank spaces

You will turn the page, when the signal is given, and fill out as many spaces as you can in the time allowed Try to learn the combinations but do not stop to study them Write down as many letters as you can in the time given.

(Sample of blank to be filled out by subject)

Code

4	8	6	1	9	2	7	5	3
c	*f*	*a*	*m*	*e*	*r*	*b*	*o*	*t*

84,976						27,516					
75,821						37,821					
63,415						97,413					

Experiment I. Here we used the direction sheet as shown above and five substitution sheets with codes as follows

(1)	4	8	6	1	9	2	7	5	3
	c	*f*	*a*	*m*	*e*	*r*	*b*	*o*	*t*
(2)	5	2	7	4	8	6	3	1	9
	t	*c*	*e*	*a*	*m*	*r*	*o*	*f*	*b*
(3)	6	3	5	9	2	7	1	8	4
	m	*a*	*r*	*f*	*o*	*c*	*b*	*e*	*t*
(4)	2	7	1	8	5	3	9	4	6
	f	*o*	*r*	*t*	*a*	*b*	*m*	*e*	*o*
(5)	3	5	9	6	4	2	8	7	1
	e	*m*	*b*	*f*	*r*	*a*	*o*	*t*	*c*

The time given for each substitution sheet was three minutes in

which to work, and a two-minute rest interval was allowed between successive repetitions to avoid fatigue

Experiment II In Experiment II we used the direction sheet as shown on page 140, but one and the same code was used for ten successive repetitions The time was reduced in this experiment, one minute being allowed for each repetition in which to work, and one-minute interval between successive repetitions for rest

Experiment III A further analysis of our problem involved the use of certain of the materials in our first experiment with some significant supplementations Here we used the same directions and the five substitution sheets with codes as described in Experiment I. The time given for each substitution sheet was also the same as that used in Experiment I. In addition to the above material, however, a *retention sheet* was used, and, after the student completed his three-minute work period, he was asked to look at a code on the retention sheet and leisurely write the proper letters for the corresponding numbers of the code This supplementation was introduced to see how well the students were learning and retaining the code

III. Results

1. *Individual Differences in Associative Capacity* A survey of the data of Experiment I shows that there are wide variations among individuals in performing this task A study of the scores obtained from 247 students (Table 1) reveals a wide range of variation for each of the five repetitions of the experiment

Standard deviations (Table 2) show that the degree of variability is about the same for each repetition, which indicates that practice does not tend to eliminate the differences found in associative capacity.

Correlations of +.78, +.81, and +.84 obtained between the second and third, third and fourth, and fourth and fifth repetitions, respectively, of Experiment I prove further that the differences are not canceled as a result of practice, but approach a constant. The final proof of this constant is reached in our Experiment II

In order to analyze and study more accurately the problem involved in associative capacity we used Experiment II, which is composed of ten successive repetitions of one code. Table 3 indicates clearly the variability of performance of 145 freshmen students who acted as our subjects for this experiment. The scores show great

variability and one just as marked as that which we found in Experiment 1 Here we used the same code throughout the ten repetitions, while in Experiment I the code was different for each repetition. Regardless of the many repetitions of the same code, the individual differences persist, and, with this in mind, it is interesting to study Figure 1, which gives the quartiles for each repetition These quartiles present conclusive evidence that, instead of a cancellation of individual differences due to practice, there is a maintenance of the differences throughout the practice, that is, the quartiles show that the superior performers stay superior, on the average, and the average and inferior performers are unable to cut down the lead of the superior subjects Also, a study of Figure 1 indicates that the middle and lower quartile groups have reached the extent of their ability in this function, while the upper quartile group is still improving and gaining in ability. Projections of the curves show that

TABLE 1
FREQUENCY FOR EACH OF FIVE REPETITIONS

Scores	Repetitions First	Second	Third	Fourth	Fifth
30- 39	1				
40- 49	11	1			2
50- 59	27	7	8	5	2
60- 69	55	19	15	12	12
70- 79	61	38	50	37	31
80- 89	47	61	56	51	40
90- 99	27	55	57	59	61
100-109	16	44	41	53	61
110-119	2	16	14	20	22
120-129		5	4	6	7
130-139		1	2	4	6
140-149					3

Total number of students=247

TABLE 2
QUARTILES, MEANS, AND STANDARD DEVIATIONS FOR 247 SUBJECTS IN EXPERIMENT I

Repetitions	Q_3	Q_2	Q_1	Mean	S D
1	86.5	75.0	64 2	75 4	15 5
2	101 0	89 6	79.1	89 6	16.1
3	99 9	89.0	77 8	89 1	16 0
4	104 0	93 0	81.5	92 8	16 0
5	106 2	96 0	83 7	95 3	16 3

TABLE 3

QUARTILE DEVIATIONS, MEANS, AND COEFFICIENTS OF VARIABILITY $\left(\frac{Q}{Q_2}\right)$ FOR 145 SUBJECTS IN EXPERIMENT II

Repetitions	Q_3	Q_2	Q_1	Quartile deviation (Q)	Mean	C. V
1	31 2	26 6	21 2	5 0	26 3	18 7
2	37 9	33.5	29 5	4 2	33 5	12 5
3	40 1	35 7	31 0	4 5	35 8	12 6
4	43 7	38 1	32 8	5 4	38.8	14 1
5	46 6	41 0	35 9	5 3	41 7	12 9
6	48 1	42 5	37 0	5 5	42 7	12 9
7	50 6	44 0	38 5	6 0	44 7	13 6
8	55 5	47 9	41 6	6 9	48 6	14.4
9	57.2	49 2	42 7	7.2	50 2	14 6
10	59 0	50.4	42 1	8 4	50 4	16 6

individual differences will increase greatly from the tenth repetition.

While our quartile lines have shown decisively that individual differences are maintained throughout practice, it is, of course, possible that the individuals or subjects may be changing places in a way to compensate for a possible constriction. Correlations will dispose of this difficulty

Correlations obtained between pairs of successive repetitions of Experiment II present an interesting picture indeed.

First and second repetitions		.65
Second and third	"	.69
Third and fourth	"	.72
Fourth and fifth	"	.84
Fifth and sixth	"	.83
Sixth and seventh	"	.78
Seventh and eighth	"	.87
Eighth and ninth	"	84
Ninth and tenth	"	.81

From these correlations it is seen that there is probably a constriction or coming-together of subjects during the adaptation period of four repetitions, but, after this, the correlations average a constant, which indicates that there is no trend of any sort toward a cancellation of individual differences or change of places among subjects The differences that prevail at the outset or adaptation stage of learning remain constant or tend to increase during the facilitation stage of learning We have designated the early stage

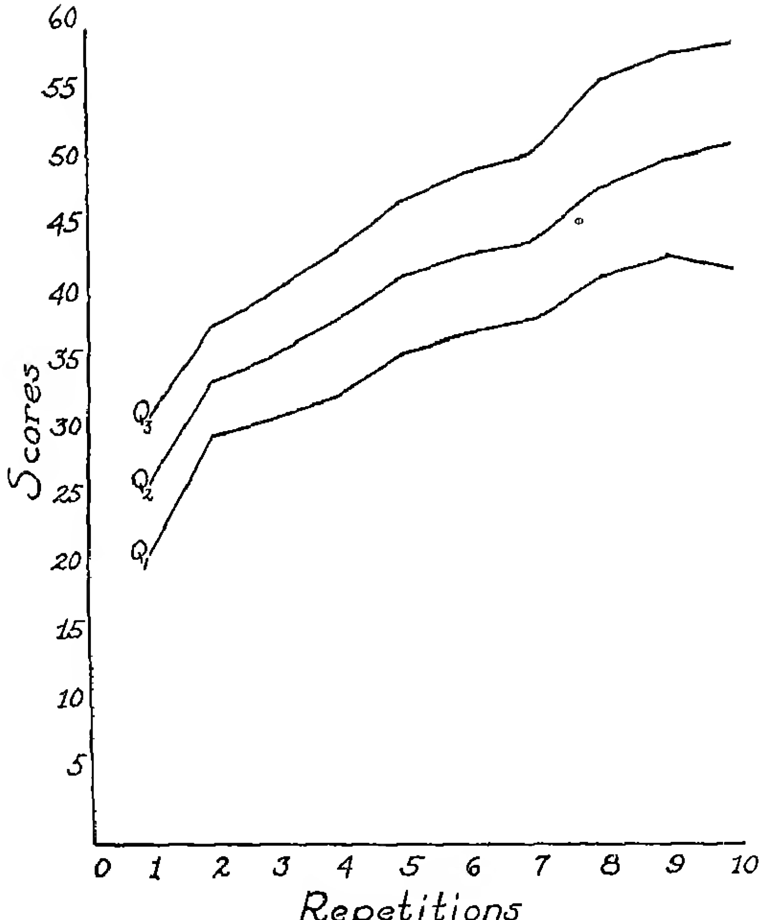

FIGURE 1
QUARTILES FOR 145 SUBJECTS—EXPERIMENT II

of the learning curve where construction takes place "the adaptation stage," and the remainder of the curve where individual differences are more constant, "the facilitation stage"

It is acknowledged by the majority of psychologists that, if the differences involved in any learning function are not due to past

training, then they rest upon the physical state of the subject or are the result of inherited capacity. If the differences at the beginning of practice are due to inherited capacity, then practice would either increase these differences or maintain a constant, while, if the differences before practice are the result of training, then, with equalized practice for all, the differences would tend to be eliminated. The results of Experiments I and II show that there are wide differences in associative capacity and that they persist regardless of the amount of practice involved

Efficiency and retention. We thought that the differences shown in Experiments I and II might be due to superior ability of the superior performers to retain the symbols of the code, so Experiment III was given to 200 students A rather interesting discovery was made here, for we found that statistically the slower performers were just as capable and efficient in retaining the symbols of the code as the faster performers. A correlation of only 17 ± .033 was obtained between the ability to retain symbols and the ability to substitute, which shows that the slower performers retain about as well as the faster performers. Enough has been shown to prove the existence of variability among individuals in associative capacity This variability is not the result of training, or even of learning, therefore, it would seem, from Experiment III above, to be a matter of speed of functioning of neural patterns. Individuals differ in their capacity to make and record associations due to this speed-of-functioning principle.

2. *Sex Differences in Associative Capacity* Our study of sex differences shows that the girls are far superior to the boys in associative capacity The difference is so great between the 139 male and the 108 female subjects that the experimental coefficient, McCall's device for showing reliability of a difference, will average 2 36 for the sum of the fourth and fifth repetitions of Experiment I, which indicates a difference too great to be due to chance. Table 4 gives the quartiles, medians, means, and standard deviations for the male and female subjects.

The sex differences manifest in our study are sufficiently large to be regarded as an important phase of the problem The girls as a group are speedier than the boys and possess superior ability at all levels of the learning.

FIGURE 2

QUARTILES FOR 139 MALES AND 108 FEMALES

TABLE 4

QUARTILES, MEDIANS, MEANS, AND STANDARD DEVIATIONS FOR 108 FEMALES AND 139 MALES IN EXPERIMENT I

Repetitions	Q_3	Q_2	Q_1	Median	Mean	S D
			108 Females			
1	101.6	80.8	72.0	87.7	81.0	22.2
2	106.0	96.7	86.2	96.6	95.9	15.1
3	104.6	94.7	83.7	94.6	94.5	15.6
4	107.8	98.2	87.5	98.7	97.9	15.2
5	109.1	101.2	90.0	101.0	100.6	14.3
			139 Males			
1	81.1	69.2	61.1	69.1	71.1	15.0
2	94.9	84.8	74.5	84.7	84.7	15.3
3	95.6	84.6	74.2	84.5	85.0	16.0
4	99.2	89.1	76.7	89.0	88.4	16.8
5	102.3	92.5	78.3	92.5	91.2	18.0

3 *Structure and Process of Learning Involved in Associative Capacity* Our study of the differences in associative capacity appears to conform with those of Thorndike, Starch, and Whitley in that practice does not decrease individual differences Realization of these significant differences aroused our interest and led us to inquire into the structural basis of the differences we had found in associative capacity Since we were convinced that these differences in associative capacity were due to a structure of some kind that was capable of functioning at a certain rate, we analyzed this learning process further to seek a logical structural basis for these differences

The learning process involved in our study is something like the following. After the learner has made himself acquainted with the directions for the test, he proceeds as follows: As in the sample on page 140, the learner is first confronted with the number 49,635 He sees the number 4 and then looks in the code and finds the letter *t*, which is the symbol for 4 Then he proceeds to the next figure, which is 9, and he finds in the code the letter *e*, which is the correct symbol for the number 9 The learner continues such a process until he does not have to refer to the code, from which time his efficiency is merely a matter of the speed of appearance of the correct symbols for the numbers of the test In other words, we are dealing with a series of events which is first spread out in time, then, as the act is repeated, this succession of events undergoes con-

striction. In the process of constriction successive elements move toward simultaneity of occurrence, which leads to a cancellation and dropping-out of some of the elements. The dropping-out of the looking-at-the-code step is made possible by the appearance of the visual image of the code, which is followed by the writing of the symbol. With more practice, the visual image drops out and the sight of the element in the substitution sheet is followed at once by the writing of the correct symbol. Nothing has happened but a temporal contraction of the events in the original series A synthesis of elements has taken place by a process of telescoping. This can be seen by an analysis of any one of the steps usually conceived of as discrete Thus the actual visual image of the correct symbol is itself not a discrete or static thing, but instead is a sequence of events such as adjusting the eyes to the code, incipient movements of writing and so on—a sequence that has already undergone a large amount of contraction with a dropping-out of non-essentials. The coordination is not a sequence of discrete elements such as a succession of dots on this page, but rather a group of parallel horizontal lines which overlap, forming stair-steps A pile of boards at the lumber yard with the higher boards receding gradually is a good figure A coordination, or any analyzable part of a coordination, is such a pile As learning proceeds the overlapping is increased. Thus elements at the beginning in clear succession undergo such a contraction that later elements appear not only earlier but in part simultaneously with their predecessors. It is this simultaneity of occurrence which leads to the dropping-out of non-essentials. The view here proposed is similar in form to the Gestalt conception of "closure" It was presented by Snoddy in his analysis of mirror-tracing in 1920 and in a later study in 1926

IV. Interpretation of the Results

Present theories of interpreting associative capacity, such as those of Hollingworth, Pavlov, Watson, and the Gestalt conception, are not adequate to interpret our data since they cannot be reduced to a functioning base

Hollingworth (7) and Watson (24) ignore the question of differential capacity, consequently they do not support their theories with a physiological basis

Pavlov and the Gestalt psychologists realize the necessity of physiological explanation, but their interpretations do not suffice for our study because of their failure to present material concerning individual differences

Our findings show that the slowest performers when given adequate time in a recall test can record as many accurate associations as the more rapid performers. At once we see that individual differences must turn on speed of *functioning*, rather than upon speed of *formation* of associative patterns, which is learning as usually conceived Furthermore, practice does not reduce or cancel individual differences found at the beginning of learning The absolute rate of improvement falls as practice proceeds, hence our superior subjects cannot have reached their high position from experience, since this would have led to a low rate of improvement, and their superiority would have been reduced greatly by the inexperienced subjects with high rate of improvement. Our individual differences are real, final, and are not due to experience. They must be due to the speed of functioning of physiological patterns or adjustments

The results obtained in this study confirm the results Snoddy found in an entirely different performance, mirror-tracing. He likewise found that practice does not alter individual differences, and that a basic capacity of some nature—in particular, he proposes stability or endurance capacity—is necessary to explain individual differences. Every normal individual possesses initially the capacity to go over the steps of our simple task, and it is our view that the differences that exist among individuals in associative capacity are to be explained in terms of differences in the time of functioning, which, in turn, depends upon the stability or the endurance capacity of these sensorimotor patterns to endure stimulation; thus, we find here the same basis for the learning as proposed by Snoddy for motor learning. In other words, the stability or endurance capacity of sensorimotor patterns determines how much stimulation a pattern of coordination can endure It is not a matter of the ability to establish certain connections or form associations, for the differences are not due to formation of the patterns, but rather to the speed of functioning of those already there. Learning is merely the increase of the ability to endure stimulation The total pattern is there at the beginning; it undergoes contraction which involves the dropping-out of many elements, the increase of stability, and the increase of speed of functioning.

V CONCLUSIONS AND SUMMARY

In this study of the structure of, and the individual differences involved in, associative capacity we have used a simple test of associative capacity and have attempted to explain the structure and differences involved in associative capacity

We have found in a special study of digit-symbol retention under conditions of slow recall, after large individual differences had been established through repetition, that the very slowest subjects were as efficient as the faster performers in number and accuracy of retained elements This presents a most important point in this study, for the individual differences in associative capacity thus seem not to be due to learning or retention as usually conceived, but rather to certain differences in speed of functioning

The individual differences persist through all the repetitions of the test, therefore practice does not reduce or cancel the differences found in the outset of learning. Rather, the differences are maintained throughout extended practice, which shows that the variation among individuals is not due to past experience.

Since past experience or learning is not responsible for the differences in associative capacity, it appears that a capacity of some nature is necessary to explain the differences involved in this function This capacity is not a matter of the formation of associations but simply a matter of the speed of functioning of total patterns Our results show varying degrees of performance, and this variation is reduced to the stability or endurance capacity of neuromuscular patterns to endure stimulation. Large sex differences were discovered in this study, and the higher efficiency of the girls in making substitutions is conceived to be due to their greater speed of function.

In an entirely different study, mirror-tracing, Snoddy has found that neuromuscular patterns possess a specific stability and endurance capacity, and that individual differences involved in his study and in similar abilities could be reduced to the stability or endurance capacity of neuromuscular patterns to endure stimulation

The stability of the patterns involved in associative capacity seems to depend upon the neuromuscular apparatus, and the efficiency of this apparatus seems to depend upon certain growth processes, and also upon its inner state, which, in turn, would be expected to vary considerably with variations in health, heredity, and emotional state

References

1. ANREP, G V. The irradiation of conditioned reflexes *Proc Roy Soc*, 1923, 94B, 404-426
2 DERCUM, F X The physiology of mind an interpretation based on biological, morphological, physical, and chemical considerations (2nd ed) Philadelphia: Saunders, 1925 Pp. 287
3 HARTLEY, D Observations on man, his frame, his duty, and his expectations (2 pts) London, 1749 (Reprinted London: Johnson, 1791 Pp 512, 455)
4 HENSEN, V Ueber das Gedachtniss Kiel Universitatsbuchh., 1877. Pp 18
5 HERING, E On memory and the specific energies of the nervous system Chicago Open Court, 1895 Pp 50
6 HERRICK, C J Brains of rats and men a survey of the origin and biological significance of the cerebral cortex Chicago: Univ Chicago Press, 1926 Pp xiii+382
7 HOLLINGWORTH, H. L. Psychology its facts and principles New York: Appleton, 1928 Pp xviii+539.
8 HUME, D A treatise of human nature (3 vols) London, 1874 (Reprinted and edited by T. H Green and T H Grose, London Longmans, Green, 1909 Pp xvii+565, xii+472)
9 KAPPERS, C U A The phenomena of neurobiotaxis in the central nervous system 12th *Int Cong Med*, 1914, Sec I, Pt 2, 109
10 KIRBY, T J Practice in the case of school children *Teach Coll Contrib. Educ*, 1913, No 58. Pp vi+98
11 KOFFKA, K The growth of mind an introduction to child psychology (Trans by R M Ogden) New York, Harcourt, Brace, London, Kegan Paul, 1924. Pp xvi+383 (2nd ed., 1928 Pp xix+427)
12 KOHLER, W The mentality of apes (Trans by E Winter) New York Harcourt, Brace, London Kegan Paul, 1925 Pp. viii+342.
13 LEWIN, K Das Problem der Willenmessung und das Grundgesetz der Assoziation *Psychol. Forsch*, 1922, 1, 191-302, 2, 65-140.
14 LUND, F H Psychology the science of mental activity New York, Seiler, 1927 Pp 488
15. MEUMANN, E The psychology of learning (Trans. by J W Baird) New York Appleton, 1913 Pp xix+393
16. PAVLOV, I P. Conditioned reflexes an investigation of the physiological activity of the cerebral cortex (Trans and ed by G V Anrep) London Oxford Univ. Press, 1927 Pp. xiv+430
17. SEMON, R Die Mneme als erhaltendes Prinzip im Wechsel des organischen Lebens (2nd ed) Leipzig Engelmann, 1908 Pp 391.
18 SNODDY, G. S Learning and stability *J Appl Psychol*, 1926, 10, 1-36
19 STARCH, D Transfer of training in arithmetical operations *J Educ Psychol*, 1911, 2, 306-310
20 THORNDIKE, E L Educational psychology Vol III Mental work and fatigue and individual differences and their causes New York Teach Coll, Columbia Univ, 1914 Pp x+408

21. ———. Educational psychology: briefer course New York. Teach Coll Columbia Univ, 1914 Pp xii+442
22. TITCHENER, E B A beginner's psychology New York. Macmillan, 1915 Pp xvi+362.
23. WARREN, H C A history of association psychology New York: Scribners', 1921 Pp ix+328.
24 WATSON, J. B Behavior: an introduction to comparative psychology. New York Holt, 1914. Pp xii+439.
25 ——— Psychology from the standpoint of a behaviorist Philadelphia: Lippincott, 1919 Pp ix+429 (2nd ed, 1924)
26. ——— What the nursery has to say about instincts *Ped Sem*, 1925, **32**, 293-326
27 WELLS, F. L The relation of practice to individual differences *Amer. J Psychol*, 1912, **23**, 75-88
28 WHITLEY, M T. An empirical study of certain tests for individual differences. *Arch. Psychol.*, 1911, No 19. Pp 146

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UNE ÉTUDE DES DIFFÉRENCES INDIVIDUELLES DANS LA CAPACITÉ D'ASSOCIER

(Résumé)

Dans cette étude de la structure de la capacité d'associer et des différences que l'on y trouve, on a employé un simple test de capacité d'associer et l'on a essayé d'expliquer la structure et les différences individuelles que l'on y trouve.

Dans une étude spéciale de la retention des chiffres et des symboles dans les conditions d'un rappel lent, après que de grandes différences individuelles s'étaient etablies par répétition, les sujets les plus lents se sont montres aussi capables que les plus rapides à l'égard du nombre et de l'exactitude des éléments retenus Cela présente un point très important dans cette étude, car les différences individuelles dans la capacite d'associer semblent ainsi n'être dues ni à l'apprentissage ni à la rétention selon leur conception ordinaire, mais plutôt à certaines différences dans la vitesse du fonctionnement

Les différences individuelles persistent dans toutes les répétitions du test, ainsi l'exercice ne réduit ni ne rend nulles différences trouvées au commencement de l'apprentissage Plutôt, les différences se maintiennent dans l'exercice étendu, ce qui montre que la variation entre les individus n'est pas due à l'expérience antérieure

Les résultats montrent des degrés variants de la capacité d'executer, et cette variation est réduite à la stabilité ou à la capacité des formes neuromusculaires de supporter la stimulation On a decouvert de grandes différences de sexe dans cette étude et l'on croit que la plus grand capacité des filles de faire des substitutions est due à leur plus grande vitesse de fonction

HARTER

EINE UNTERSUCHUNG INDIVIDUELLER UNTERSCHIEDE IN DER ASSOZIATIVEN FAHIGKEIT

(Referat)

In dieser Untersuchung der Struktur und der individuellen Unterschiede der assoziativen Fahigkeit gebrauchten wir einen einfachen Test fur die assoziative Fahigkeit und versuchten die damit verbundene Struktur und individuellen Unterschiede zu erklaren

In einer besonderen Untersuchung uber das Behalten von Ziffersymbolen unter den Bedingungen einer langsamen Erinnerung, nach der Erstellung grosser individueller Unterschiede durch Wiederholung, fanden wir, dass die langsamsten Versuchspersonen so leistungsfahig waren wie die schnellsten in Bezug auf Anzahl und Genauigkeit behaltener Elemente Dies stellt einen sehr wichtigen Punkt dieser Untersuchung dar; den darnach scheinen die individuellen Unterschiede in der assoziativen Fahigkeit nicht auf dem Lernen oder dem Behalten zu beruhen, wie sie gewohnlich verstanden werden, sondern eher auf gewissen Unterschieden in der Geschwindigkeit der Verrichtung

Die individuellen Unterschiede bestehen hartnackig durch alle Wiederholungen des Tests, Übung vermindert oder annulliert daher die Unterschiede nicht, die am Anfang des Lernprozesses festgestellt werden Die Unterschiede werden eher durch die ausgedehnte Übung erhalten, was zeigt, dass die Variation unter Individuen nicht auf vergangener Erfahrung beruht.

Unsere Ergebnisse zeigen variierende Grade der Leistungsfahigkeit, und diese Variation lasst sich auf die Stabilitat oder Ausdauer neuro-muskuloser Muster (neuro-muscular patterns), Reize zu ertragen, zuruckfuhren Wir stellten in dieser Untersuchung grosse Unterschiede zwischen den zwei Geschlechtern fest, die grossere Leistungsfahigkeit der Madchen in der Erstellung von Substitutionen beruht wohl auf ihrer grosseren Funktionsgeschwindigkeit

HARTER

CASE STUDIES OF MATURE IDENTICAL TWINS*[1]

From the Institute of Child Welfare, University of California

HAROLD D CARTER

In the study of twin-similarities as an approach to the problem of untangling nature and nurture effects, the data obtainable from mature identical twins have been almost entirely neglected[2] Much argument has taken place concerning the tendency of twins to grow more or less similar as they grow older, but the studies undertaken have been limited largely to school children. Consideration of the underlying argument suggests that more significant data are to be obtained from the intensive study of pairs of mature identical twins Such data are valuable for study of effects of differences in training and experience which continue over a period of years The results should be readily interpretable when sufficient case studies have accumulated, as the differences in environment are often quite distinct and specific as to type, but quantitatively different for various cases, so that comparative analysis will ultimately be possible.

Because one does not know in advance what factors to study, and because trends of present-day theory give the procedure ample justification, the presentation of detailed data on single pairs seems desirable. These intensive semi-clinical studies with small numbers of cases can never solve the problems completely, but they do furnish valuable clues and may serve as a foundation for efficient statistical studies which will enable one to determine the facts with greater precision.

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[1]This study was undertaken as part of an intensive research on twins which the writer conducted at Stanford University, as Social Science Research Council Fellow Grateful acknowledgment is made to Dr Lewis M. Terman for helpful advice and criticism throughout the course of the investigation. The writer is also indebted to Dr H S Conrad, Dr R C Tryon, and Dr H. E Jones, who read and criticized the manuscript

[2]Attention is called to the work of Newman (9-14) and Muller (7) These are studies of mature identical twins who have been reared apart This technique is especially valuable, but in view of the fact that such cases are comparatively rare there is a very real advantage in making use of the additional material to be obtained from study of all available pairs of mature identical twins

With such considerations in mind, intensive data have been secured on over 40 pairs of twins, including 10 young and 10 mature identical pairs It is hoped that an accumulation of this type of data will help in the attempt to evaluate the contributions of *specific* types of environmental factors. The case here reported, which is the third in the series of mature pairs studied by the present investigator, reveals some of the advantages and disadvantages of intensive study of mature identical twins as an approach to the study of nature and nurture effects It is an account of a pair of twins whose environments have been very similar in early life, but different during adult life, in spite of separation for a period of 20 years, and in spite of certain very distinct differences in environment, the twins show very slight differences in personality, and have remained remarkably similar in mental ability.

Some of the other mature pairs who have been studied by the writer (3) *do* show consistent differences. Those cases are especially interesting, but it would be a mistake to consider them of any greater theoretical importance The peculiar effectiveness of strange phenomena for gaining our interest must not blind us to the importance of findings which happen to be in line with more conservative theory In the present case, there is an environmental difference which did not cause the twins to become different — and it might have It may be that there are factors working in both directions, which balance each other and make the problem more complicated than it appears on the surface. Such individual case studies as are here presented provide the data to answer certain questions definitely, and incidentally provide many suggestions which need to be verified by further research.

Case III. Twins L A and D. A

Twins L A and D A are women, 43 years of age at the time of the examinations By use of the techniques outlined by Bonnevie (2), Dahlberg (4), Muller (7), Siemens (17), Newman (8), and others, the twins were diagnosed as monozygotic Since they are of the extremely similar type, this diagnosis was easy, and there can be hardly the slightest doubt of its accuracy However, detailed data on physical resemblances are presented because of

the possibility that degree of physical similarity is indirectly related to development of similarities in personality and achievement.

Careful examination of photographs of the twins taken at the ages of 2, 3, 4, 5, 12, 16, and 20 years showed striking similarity at all these ages D and L are very much alike, even in comparison with other monozygotic twins At a time shortly before the examiner's first visit, one of D's young sons (aged 5 years) mistook L for his mother! The twins live in small towns, not far apart, and it is a frequent occurrence for friends to mistake one for the other When either twin visits the town in which the other lives, she is likely to be greeted by persons who are total strangers to her, but who know her twin. Table 1 presents some numerical data concerning physical resemblance

TABLE 1

PHYSICAL RESEMBLANCE OF THE TWINS

		L A	D A
Height in inches		66 75	67.00
Weight in pounds		200	180
Head size *a* Length		18.0 cm	18 0 cm
b Width		14 8 cm.	14 7 cm.
Eye color		Brown, very dark	Same
Hair color, at present		Gray	Same
formerly		Dark brown	Same
Ear form		Small, no free lobe	Same
Strength of grip,	R	36 0 kg	28.7 kg.
Av of 3 trials	L.	31.7 kg	26.3 kg.
Speed of tapping,			
Av of 3 trials	R	69 0	68 0
of 10 sec each	L	62 0	58 5

The twins can wear each other's shoes, stockings, hats, and gloves L's coats and dresses are somewhat larger at present, although when younger there were absolutely no differences

Their great physical resemblance is indicated by the fact that persons seeing them together *always* guess them to be twins Their friends, relatives, teachers, etc., and even their own father, could not tell them apart. It takes a long time for persons to learn to distinguish them, and some have never been able to do so Their father once spanked D twice, at the age of 12, under the impression that he was punishing both twins He never tried to learn to distinguish them (according to report), as he felt it made no difference in any way, and he regarded them as equivalents.

Asymmetry

No intensive study of asymmetry has been made, but some of the infor-

mation available contributes to the problem incidentally. D states that her left eye is better than her right, L reports that both eyes see equally well. Both twins are right-handed, and there is no indication of any early tendency for one to be left-handed or ambidextrous. L has a son who is left-handed, and D has a son who was a mirror-writer and mirror-reader. The general indication is one of the same-sided symmetry for D and L.

Finger-Prints

The finger-prints of the twins were examined, using the techniques outlined by Bonnevie (2). Table 2 shows the quantitative values for each finger separately.

TABLE 2

Showing the Similarities and Differences of Quantitative Values of Finger-Prints for the Twins

The raw ridge-counts have been classified according to Bonnevie's method (2).

	L. A.		D. A.	
	Right	Left	Right	Left
Thumb	3.5	4.0	8.0	3.0
Forefinger	4.0	2.5	2.5	2.5
Middle finger	3.0	3.5	4.0	v0
Ring finger	4.0	7.0	6.5	7.0
Little finger	3.5	3.5	3.5	3.5
Total, each hand	18.0	20.5	24.5	19.0
Total, both hands	38.5		43.5	

From Bonnevie's Table XXII it appears that the average difference in quantitative indices for her 15 pairs of identical twins was 6.02, and the range was from 0.5 to 18.9. For her 16 pairs of fraternal twins, the average difference was 16.09 and the range was from 6.0 to 34.0.

The patterns are of very similar type and design, and the difference in total quantitative values here is 5.0, which is about median for identical twins. Such similarity of ridge-count classification values is rarely found in fraternal pairs. The prints themselves are presented, in order that persons specially interested in these problems may study them in greater detail.

Developmental Data

L was born 16 hours before D, and at birth each weighed 5 pounds. Their mother died soon after their birth. Both entered school at the age of 6 years. At the age of 12 years, both temporarily lost their hair, supposedly as a result of a severe fever. Later in life, their hair remained the same in color throughout the process of graying. L has always been

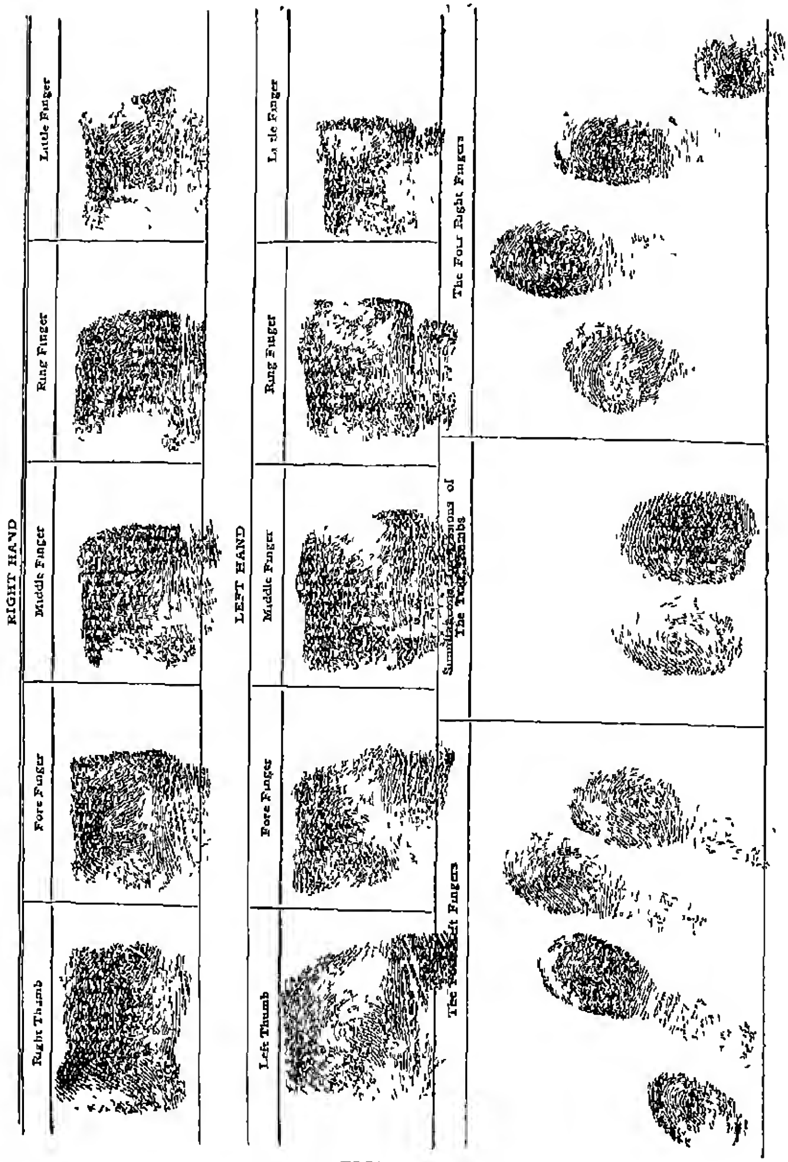

FIGURE 1
Finger-Prints of L A

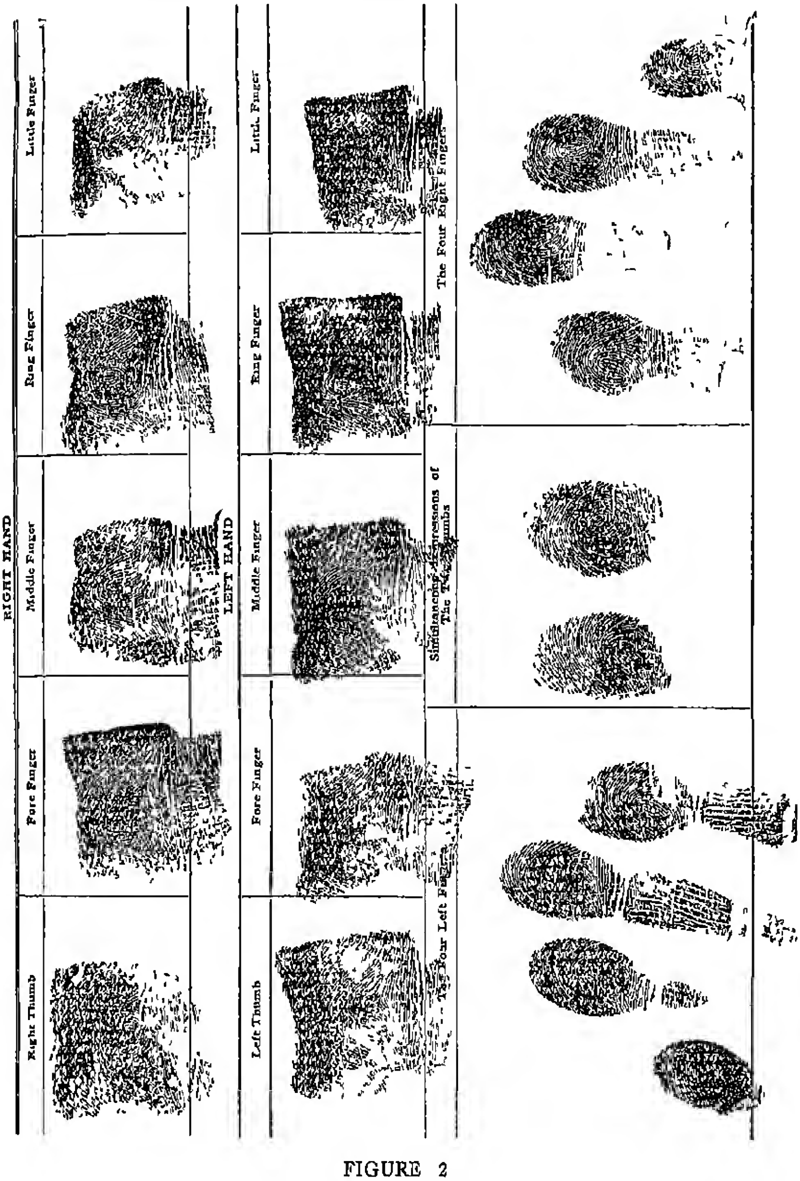

FIGURE 2
Finger-Prints of D A.

sturdier and more energetic She menstruated first at the age of 11 or 12 years, while D did not reach this stage of development till after the age of 14 or 15 Since age 20, L has weighed about 20 pounds more, on the average, than her twin.

The following information concerning illnesses was obtained by conferences with the twins separately, and with their foster mother, and it is probably fairly accurate. Both had whooping-cough at the age of 6 months, and again at 12 years, and D is supposed to have suffered a third attack at the age of 23 Both twins are reported as having had measles at the same time, on three different occasions, when about 6 or 8 years of age At the age of 22 they had smallpox, L having a light illness which preceded by a short time the more severe attack which D had Both had chicken-pox, D having it less severely In their preschool years, D had pneumonia twice, and L three times At about the age of 26 years, D began to develop a goiter, while living in Walla Walla, Washington, where it was prevalent. It became very serious, and two years later she had the goiter removed, since then she has had a heart ailment which has been rather troublesome at times but at present seems to have been overcome. L has not had any indication of goiter or of heart trouble.

Early Environment

During early life, the two were together most of the time, when separated for a whole day for the first time, at the age of 4 years, they cried almost all day. The first separation which lasted longer than a day was at the age of 20 years, when L went away from home to teach, and was gone for several months The twins dressed the same till the age of 16, and from then on till the time of separation they wore clothes of the same pattern but of different materials

Their childhood acquaintances were the same, but their close friends were not, because their reactions to persons were different. L matured earlier and her friends included boys long before D was interested in the opposite sex, the two never showed similarity in their choices of male companions When young, D sometimes acquired a dislike for the boys who captured her twin's attention

Schooling

The twins were together in school for twelve years and took the same courses They took music lessons at home (piano and voice) together for about 6 years, but L has continued this interest in

later life more than has D. Another hobby was art; in this they had the same courses in the grades and in high school, but since that time L has had little formal training, although she has maintained her interest in the subject. D, however, has had two years additional art training in a teachers college (i.e., took all the art courses she could get during those two years), a summer's training at an art school, and two more years of training in arts and crafts in another city.

The twins attended grade school in a city of population about 200,000 and attended high school in a small town. After this their experiences were different: L took three summer sessions of teacher-training in various schools, and taught in elementary school, at first teaching all eight primary grades; D continued with the training in art mentioned above.

Adult Life — The Main Differences in Environment

L was married first, at the age of 23 years, and D was married five years later. Each has three children. Since her marriage, L has lived in a small town in California, and has made only occasional short visits in Washington and Oregon. L's husband is a technician in photographic art, whose business keeps him largely in one locality. D married a man interested in education as a profession, whose work permits, and has in the past favored, a great deal of travel.

Both twins lived in a city till the age of 16, and the next four years lived in a small town. L has continued to live in the small town, but D has moved about, living in a small city one year, a larger city one year, and in a different state for two years. Up to this time, she, too, had remained on the Pacific coast. Then she went east, and lived in Massachusetts for nine years, in New York for four years, and, returning to the west, lived in Washington for five years, and in a small town in California for one year. She has been in Boston, Philadelphia, Richmond, Chicago, and various places in Canada where her twin has not been. She has visited Banff, Lake Louise, the Grand Canyon, Yellowstone Park, and many other places which her twin has not visited.

L has had about five years of full-time teaching experience, and at present teaches the first four grades in a school in the small

town in which she lives, in addition to carrying on her duties as housewife. D has taught art at various times, and at present teaches art classes two afternoons a week Both twins appear to have considerable talent for drawing and painting, but perhaps less capacity for aesthetic judgment than is required for outstanding achievement in art. Although both have won prizes in art, D has devoted more time to it, and has won more

L's teacher-training and teaching experience are certainly important environmental factors. On the other hand, D's travels, and varied experiences, certainly have occasioned adjustment to a *variety of situations which L has not had occasion to meet* It might be expected that such opportunities as D has had would favor better adjustment in the life of the individual, and they might very well alter development in a number of ways, through providing different kinds of stimulation, and indirectly affecting drives. Travel has long been considered an important educational factor, and the intensive study of cases such as this should shed some light upon its effects.

Personality Traits

Some general facts concerning the twins' personalities have been obtained through observation and through interviews with the twins and with their foster mother According to report, L is retiring and lacks a sense of humor, while D is forward and has an over-abundance of humor. Other persons think that when the twins are together they are more at ease and more pleasant, L is more jolly, and D is more talkative. The twins state that one makes up for the qualities which the other lacks.

L's daughter, aged 19, and son, aged 16, could not name any differences in personality traits of the twins, even when confronted with a long list of specific questions The twins' foster mother reports, however, that L has always been the more self-confident and aggressive, and that when young she usually took the lead It is reported by D that their foster mother liked L better, and this appears to be true. It is related to the fact that D was less sturdy, and her twin was more willing to do various little duties about the home when they were young. D was considered a bit lazy

At the age of 20 years both were supposed to go away from home to teach, and both had appointments, but D was timid, and

shrank from this new adjustment, when the time came, she backed out of it entirely. This timidity has disappeared now, perhaps as a result of much experience with people, occasioned by her rather extensive travels At present, L is the one who feels less confident in social gatherings, but the difference is slight.

L is considered by their foster mother to be more practical, more serious-minded, and a better organizer. An aunt, who knew them from the time that they were babies, states that L is more practical, and D more sentimental. She appeared not to know of any other specific personality differences. Her husband (uncle to the twins) could not answer any of the questions asked, because he never had been able to tell the twins apart

The foster mother, when asked a large number of specific questions, gave answers which indicated that the following were her opinions. first, the twins were equally interested in school, and equally capable; second, L was more sensitive and more easily hurt; third, L is a more capable entertainer, although less socially inclined, less self-assertive in a social situation, and less of a conversationalist, fourth, L has usually enjoyed better health, and has been more energetic; fifth, L has more initiative, and more imagination, while D is more excitable, more gay and lively, and more mature in personality, sixth, L is more clever, more interested in the home, more self-reliant, more solitary, and more religious.

Their foster mother feels that the twins are different in a number of ways now, but only as a result of experience. She cites as a main difference the fact that D is easier to know, happier, and less inclined to worry, while L is reserved, perhaps has some unhappiness which she keeps to herself, and, in general, does not confide in persons as readily as does her twin. Experience has changed D's personality for the better in a number of ways With a few minor exceptions, such as L's superior ability in playing the piano and reading music, the twins remain very similar in ability in spite of differences of experience The examiner feels confidence in the foster mother's statements, and what appear to be minor contradictions are caused by the smallness of the differences and the specificity of the situations to which they apply

INTERESTS

There were never any significant differences in interests, except

in their tastes for young men — in which D met with more approval on the part of the foster mother

The twins' own ratings on interests were obtained by having them fill out the four-page folder which was developed by Terman (19, pp 363-383) for studying the interests of gifted children. The results showed great similarity of interests in school subjects. Both liked English very well, except grammar. History and practical subjects were liked fairly well, as was science, but both disliked mathematics. At the present time, both enjoy reading, and prefer especially travel, history, poetry, short stories, and biography. They read the same magazines, including *Good Housekeeping, The American,* and *The Ladies Home Journal.*

Their hobbies have always been similar. As children, they made similar collections of stamps, pictures, etc They like housework; both have won prizes in cookery, and youthful accomplishments in making dresses, cooking, drawing, painting, basketry, and various forms of handiwork were very similar. L enjoys writing poems, but D finds this hard work. As young girls, they were very religious, and, as adults, both have been much interested in church work. As adolescents, both wanted to be nurses, but their parents objected, so they turned their attention to teaching.

The general similarity of interests which is revealed by answers to general questions appears upon more intensive inquiry to extend to many details

Occupational Interests

Table 3 shows the numerical scores and letter-ratings assigned to each for all 23 occupational scales of the Strong Vocational Interest Blank (18) Highest ratings were secured on those scales which measure interest in people primarily

A substantial body of data in the possession of the writer supports the conclusion that this test, although devised for men, has considerable validity for measuring the interests of women The similarity of the twins in interest profile is striking It is likely that the same individual taking the test on two occasions would not receive scores any more similar than these

Stability and Adjustment

The Cady modification of the Woodworth Questionnaire, which has been described elsewhere (19, pp 500-505), was administered

as an individual examination. An item analysis of their "diagnostic" responses suggests that L is more introverted, less stable, and less self-assertive. However, L's total score was 9, and D's was 10, which indicates that both are more than ordinarily stable, and indicates similarity rather than difference, as compared with people in general.

Tests of Personality Traits

Table 4 shows the results of several tests used for measuring traits of personality. The probable errors of measurement for some of the tests are given in Table 5. The Stanford Masculinity-Femininity Test is not yet published for general use, and has been used here with permission of the authors. Norms obtained by the writer from his small sampling of subjects indicate that the dif-

TABLE 3

SHOWING THE SCORES OF THE TWINS ON THE STRONG VOCATIONAL INTEREST BLANK

		L A		D A	
		Score	Rating	Score	Rating
1	Advertiser	6077	C	6123	C
2	Architect	6617	A	6454	B
3	Artist	6563	B—	6380	C
4.	C P A	6268	C	6301	C
5	Chemist	6344	B—	6232	C
6	Doctor	6373	B	6243	C
7	Engineer	6335	B	6232	C
8.	Farmer	6298	B	6241	B—
9	Journalist	6248	B	6217	B—
10	Lawyer	6169	C	6180	C
11	Life insurance salesman	6160	C	6169	C
12.	Minister	6561	B+	6550	B+
13	Personnel worker	6299	B—	6315	B—
14	Psychologist	6384	B—	6211	C
15	Purchasing agent	6300	B	6243	C
16.	Real estate salesman	6070	C	6054	C
17.	School man	6476	A	6468	A
18	Vacuum cleaner salesman	6186	C	6166	C
19	Y M C A secretary	6460	B	6464	B
20	Office clerk	6379	B	6447	B+
21	Physicist	6370	C	6175	C
22.	Mathematician	6496	B	6321	C
23	City school sup't	6401	B—	6399	B—

ference here discovered, though large enough to be suggestive, is not statistically reliable

Results of the Watson Test of Fairmindedness (20) indicate that D is more prejudiced. The author of this test gives a reliability of the total score of 96, and, in view of this high reliability coefficient, it is a fair guess that the obtained difference is greater than its probable error, but norms have not yet been obtained which enable one to make an exact statistical evaluation of the difference. Both twins appear to be more prejudiced than average

The data of Table 4 shows that, according to results of the Bernreuter Personality Inventory (1), D is more stable, more self-sufficient, more extroverted, and more dominant. All these differences, except that in introversion, are statistically significant.

TABLE 4

SHOWING THE RESULTS OF MEASUREMENTS OF PERSONALITY TRAITS OF THE TWINS

	L A	D A	Diff. in score	Diff / $P.E._{diff}$
Stanford M-F Test	—127.3	— 81.0	46.3	1.72
Bernreuter Personality Inventory,				
B1-N scale	— 23	—112	89	3.21
B2-S scale	— 17	40	57	3.64
B3-I scale	— 24	— 71	47	2.39
B4-D scale	— 18	80	98	4.61
Watson Test of Fairmindedness,				
Total score	184	223	39	
Percentage score	37.6	45.6	8.0	
Raubenheimer-Voelker Overstatement Test				
a Asserted score	51	43		
b. Actual score	56	62		
c. Items wrong, of those she claimed to know well	10	6		

The last column gives the difference in scores between the twins, divided by the probable error of such a difference between individual scores. See Table 5

The scores on the Raubenheimer modification of the Voelker Overstatement Test (19, pp. 489-490) indicate that both tend to

understate their amount of information, but that L understated less than D. Data for interpreting the results of this test with greater exactness will be published at a later date.

Accuracy of Measurements

In order to make the data more readily interpretable, wherever possible the writer has calculated for each test its probable error of measurement The statistical procedures involved are described by Kelley (6). The calculations are for the most part based on very small samplings (the writer's own test data), but they are the best statistics available at present for interpretation of the differences found. These data are given in Table 5

TABLE 5

Showing the Standard Deviation of Scores, the Reliability Coefficient, the Probable Error of Measurement, and the Probable Error of a Difference between Scores, for a Number of the Tests Used in the Twin Study

The first column gives the number of cases in each group.

	N	S D	Rel coeff	P E $_M$	P. E $_D$
Stanford M-F Test*	59	60 30	78	19 07	26 96
Bernreuter Personality Inventory,					
B1-N scale*	107	83 69	88	19 55	27 64
B2-S scale*	107	42 38	85	11 07	15 65
B3-I scale*	107	53 26	85	13 91	19 67
B4-D scale*	107	64 29	88	15 02	21 24
Meier-Seashore Art Judgment Test	83	10 76	75	3 63	5 13
Willoughby Intelligence Test Battery, total score	90	72 96	94	11 75	16 61
Terman Group Test, Form A, total raw score	82	37 86	95	5.71	8 07
Stanford Achievement Test, total raw score	88	133 64	.96	17 55	24 84
Vocabulary Tests A and B, Av of the two scores*	123	18 60	96	2 51	3 55
Otis Higher Examination, Form A†	253			2 62	3 70

*For the M-F test, the Bernreuter Personality Inventory, and the Vocabulary Tests A and B, these statistics are based upon groups consisting of female subjects only.

†For the Otis test, the probable error of measurement is given by the author, and has been taken from the manual (15)

The data of Table 5 are preliminary; the writer is attempting at the present time to secure additional data in order that these figures may be replaced by more accurate determinations Hence the data of Table 5 are not recommended for general use.

Differences in Ability

Table 6 shows the scores of the twins on the various ability tests, and an evaluation of the differences found, which is based on the data of Table 5. The differences favor L in the majority

TABLE 6
Showing the Scores of the Twins on Several Tests of Intelligence and Achievement, the Differences between Their Scores, and a Statistical Evaluation of Those Differences

	L A	D A	Diff in scores	Diff / PE_{diff}
Willoughby Battery, total raw score on 11 tests	395	376	19 0	1 14
Terman Group Test, Form A, total raw score	179	179	0 0	0 0
Otis Higher Examination, Form A, total score	53	48	5.0	1 35
Stanford Achievement Test, Form V, total raw score	1160	1175	15 0	60
Vocabulary Tests A and B, av of the raw scores	106	106 5	5	14
Vocab. Test M (very hard), total raw score*	96	95	1.0	
Meier-Seashore Art Judgment Test, raw score	93	94	1 0	19

* The probable error of measurement has not yet been obtained for Vocabulary Test M, but it is obvious that this difference is insignificant because the probable error of measurement will not be less than two or three points at least

of instances, but none of them is significant. It might be that a sufficiently reliable battery of tests would reveal a consistent slight superiority on the part of L, but it is not very likely. These measurements are sufficient to show that there are no differences of any practical significance. The results of the Stanford Achievement Test are interesting in view of the fact that this test measures information taught in the first nine grades of school; L has

taught all of the first eight grades and is at present teaching the first four grades, which makes the slight difference in favor of her twin seem rather surprising Another interesting fact is that D, who has had much more training in art, does not show any significant superiority on the Art Judgment Test

Superiority of the Twins

Indications of the level of ability of the twins, as compared with the population at large, are furnished by the data of Table 7

TABLE 7

Comparing the Scores of the Twins on These Tests with the Available Norms

	L A.	D. A
Bernreuter Personality Inventory percentile scores		
B1-N	52	17
B2-S	38	74
B3-I	44	10
B4-D	28	83
Willoughby Battery, standard scores*	1 57	1 26
Terman Group Test, Form A, mental age equivalent	18-0	18-0
IQ (uncorrected)	112 5	112 5
Otis Higher Examination,		
IQ (30-min time limit)	111	106
IQ (20-min time limit)	114	108
Stanford Achievement Test, educational age	18-2	18-5
Art Judgment Test, percentile score, using adult norms	41	45
Vocabulary Tests A and B, standard scores	0 72	0 75

* For the Willoughby Battery, Price (16) has shown that the mean score is 101 3 and the standard deviation is 33 0 points, using total weighted scores of 105 adult women Following his procedure in weighting, the scores were 153 and 143 for L and D, respectively.

The difficulties in determining the level of ability in relation to that of a random sampling of adults are occasioned by the fact that none of our tests has been standardized on such random adult populations Their scores on the Willoughby Battery indicate that the twins are considerably more than a standard deviation

above the mean for a group of adult women who were somewhat selected (see 16 and 21). The uncorrected Terman Group Test IQ's are about a standard deviation above the mean, but correction for age would increase their superiority. The twins are about three-quarters of a standard deviation above the mean for college freshmen in Vocabulary Tests A and B, which were taken from the University of Minnesota College Aptitude Tests

Most of the pairs of identical twins reared apart who have been studied have been of lower intellectual level. For Newman's six pairs (9-14) the average Stanford-Binet IQ was 91 4, with a range from 65 to 106, the average IQ from the Otis test (according to the writer's calculations based on the raw scores furnished by Newman) was 87 75, with a range from 69 to 99, the average Stanford Achievement Test educational age was 14-1, with a range from 12-7 to 17-3. That is, not one of those pairs is of an intellectual level equal to that of the twins in the present study. This is probably characteristic of twins reared apart. When twins are reared apart, it is usually because of necessity, and therefore they are likely to come from the lower economic and social levels. Studies of such cases will probably not include evidence on the effects of all types of environmental factors, neither are they likely to show the effects of environmental influences upon intelligence and achievement at all intellectual levels It will no doubt be easier to secure a random sampling of ordinary mature identical twins than of identical twins reared apart. These considerations lead us to believe that more studies should be made of such pairs of mature twins as are here studied, as well as of twins reared apart.

Summary

A pair of monozygotic twins, women aged 43 years, were studied intensively, by use of standard tests, observation, and interviews. Among identical twins, these would appear much more similar physically than the average They had very similar environments in early life, but as adults, for approximately 20 years, have had environments which were considerably different in a number of ways. D has traveled a great deal, and has lived in cities in various parts of the United States, while her twin has remained in a small town D's training has emphasized arts and crafts, in which she

has had several years of formal training, while her twin has merely maintained an incidental interest in art L, who has lived in a small town, has done quite a bit of teaching in the elementary grades, while her twin has taught only art

A few slight differences in personality traits are found; some of these are apparently explainable in terms of the environmental differences discovered, others, which seem to date back to early life, are not A measure of aesthetic judgment showed no difference Tests of intelligence revealed a striking similarity of scores, and scores of the two were extremely similar on a standard test for achievement in subjects taught in the elementary grades Considerable accuracy may be attributed to the findings concerning intelligence and achievement, because of the use of highly reliable standard tests, and because testing was done repeatedly, giving ample opportunity for the discovery of any differences which would be significant though small As a further refinement of technique, the differences found were evaluated in terms of the probable error of measurement, computed by the writer for each of the tests for which the necessary data were available. The personality traits of the twins show some differences, but even here, generally speaking, the more noteworthy fact is the high degree of similarity. Even the interests of the twins as measured by standard inventories appear to have remained very similar in spite of the separation and differences of experience which have continued over a period of 20 years. To sum up, the results of intensive study have shown that *the twins remained essentially very similar in spite of different experiences.*

Conclusions and Suggestions

It is inevitable, at the present state of our knowledge, that single case studies should yield suggestions more often than final conclusions However, review of this and of other similar cases (3) allows one to draw the following conclusions tentatively

1. Intensive studies of ordinary pairs of mature twins offer good material for the study of effects of environmental differences upon mental and physical traits

2 Studies of ordinary mature twins and of twins reared apart are supplementary *Ordinary mature twins usually have had similar early environments, but have different environments as adults*

3. By comparing case studies of younger and older pairs, significant data may be obtained, bearing on the old argument concerning the tendency of twins to grow more or less similar as they grow older The present lack of interpretable data bearing on this argument may be largely attributed to the fact that studies undertaken in the past have been limited for the most part to school children

4 In individual case studies of twins, it is desirable to use reliable standard tests, and to attempt evaluation of any obtained differences, in terms of the accuracy of the measuring instruments.

5 The few case studies so far made show that consistent differences in mental ability are sometimes found in pairs of twins reared together The explanation of such differences must wait until much more data have been accumulated.

6 The writer's case studies suggest that the differences which are sometimes found between pairs of mature twins are not adequately explained in terms of the obvious type of environmental differences ordinarily considered, but that their causation is very complicated It is suggested that intensive study of conditions underlying motivation in individual cases may yield important results.

References

1. Bernreuter, R G. Manual for the personality inventory Stanford University, Calif Stanford Univ Press, 1931
2. Bonnevie, K Studies of papillary patterns of human fingers. *J Genetics*, 1924, 15, 1-111
3. Carter, H. D. Identical twins reared together *J Hered.*, 1932, 23, 53-66.
4. Dahlberg, G Twin births and twins from a hereditary point of view. Stockholm Bokförlags-AB Tidens Tryckeri, 1926 Pp 296 + 85.
5. Kelley, T L Statistical method New York: Macmillan, 1924 Pp xi + 390.
6. ——————— Interpretation of educational measurements. New York World Book Co, 1927 Pp. xiii + 363.
7. Muller, H J. Mental traits and heredity *J Hered*, 1925, 16, 433-448
8. Newman, H H Studies of human twins I Methods of diagnosing monozygotic and dizygotic twins. *Biol Bull*, 1928, 55, 287-297
9. ——————— Mental and physical traits of identical twins reared apart Case I Twins A and O *J Hered*, 1929, 20, 49-64
10. ——————— Mental and physical traits of identical twins reared apart Case II Twins E and G *J. Hered*, 1929, 20, 97-104

11. ———————— Mental and physical traits of identical twins reared apart Case III Twins C and O *J Hered*, 1929, 20, 153-166

12 ———————— Mental and physical traits of identical twins reared apart Case IV Twins Mary and Mabel *J. Hered*, 1932, 23, 2-18.

13. ————————. Mental and physical traits of identical twins reared apart Case V. Twins B and D *J. Hered*, 1932, 23, 297-303

14 ———————— Mental and physical traits of identical twins reared apart Case VI Twins Ada and Ida *J Hered.*, 1932, 23, 369-377

15 OTIS, A S Manual of directions and key (revised) for intermediate and higher examinations New York· World Book Co

16. PRICE, B. The perceptual ability of persons over fifty years of age M A thesis, Stanford Univ., 1931 Pp 70

17 SIEMENS, H W *The diagnosis of identity in twins J. Hered., 1927*, 18, 201-209

18 STRONG, E. K, JR. Manual for the vocational interest blank Stanford University, Calif. Stanford Univ. Press.

19 TERMAN, L M, *et al* Genetic studies of genius· Vol 1 Mental and physical traits of a thousand gifted children Stanford University, Calif Stanford Univ Press, 1925 Pp. xv + 648

20 WATSON, G B Directions for giving and scoring the Watson Test of Public Opinion New York Bur. Publ, Teach. Coll, Columbia Univ, 1927

21 WILLOUGHBY, R R Family similarities in mental test abilities, with a note on the growth and decline of these abilities Ph D. thesis, Stanford Univ, 1926 (Publ in *Genet Psychol Monog*, 1927, 2, 236-277.)

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ÉTUDES DES CAS DES JUMEAUX IDENTIQUES D'ÂGE MÛR

(Résume)

On discute les avantages pratiques et theoriques des etudes intensives des cas de jumeaux identiques d'âge mûr, pour l'etude de la nature et de l'education, de telles donnees présentent des avantages importants, mais comprennent certaines difficultes inhérentes On donne un rapport du troisième cas d'une série, une paire de jumelles monozygotes, âgées de 43 ans. Malgré leur séparation et des différences distinctes de milieu pendant 20 ans de vie adulte, ces jumelles sont restées essentiellement semblables à l'égard de capacité, d'intérêts, et de personnalité Il a existé une différence physique importante pendant des années, puisque l'une des jumelles a severement souffert d'un goitre exophthalmique, accompagné d'une maladie de coeur très sérieuse.

L'analyse de cette étude et des etudes antérieures montre qu'il faut évaluer avec grand soin les differences obtenues dans les resultats des tests

mentaux Pour ameliorer la technique on suggère que l'on evalue statistiquement les différences obtenues entre les paires, en termes de l'erreur probable de mesure Il est évident qu'il faut employer beaucoup de précaution quand on explique les différences obtenues Dans quelques cas l'auteur a trouve des différences constantes de capacité mentale chez des jumeaux identiques Quand on trouve de telles différences, il semble qu'on ne puisse les expliquer d'une façon satisfaisante en termes du type évident des facteurs du milieu ordinairement consideré, au contraire, la causation de telles différences semble être tres complexe. Les résultats indiquent qu'une étude intensive des conditions qui se trouvent à la base des mobiles peut donner des résultats importants.

CARTER

UNTERSUCHUNGEN EINZELNER FALLE VON ERWACHSENEN EINEIIGEN ZWILLINGEN

(Referat)

Die Arbeit diskutiert die praktischen und theoretischen Vorteile, die eine intensive Untersuchung einzelner Falle von erwachsenen, eineiigen Zwillingen aufweist; solche Angaben bieten wichtige Vorteile dar fur das Studium der Natur und Erziehung, sie schliessen aber auch gewisse von Natur zugehorige Schwierigkeiten ein Man berichtet darin uber den dritten Fall einer Serie, ein Paar eineiige, 43 Jahre alte Zwillingsfrauen. Trotz ihrer Trennung und deutlicher Unterschiede ihrer Milieus auf die Dauer von 20 Jahren ihres erwachsenen Lebens blieben sie sich im Wasentlichen ahnlich in Fahigkeiten, Interessen und Personlichkeit Man beobachtete einen wichtigen physiologischen Unterschied wahrend eines Zeitabschnitts von etlichen Jahren, eine der Zwillingsschwestern hatte einen schweren exophtalmischen Kropf, der von Herzleiden sehr ernsthafter Natur begleitet war

Die Betrachtung dieser und früherer Falle zeigt, dass man in der Wertung der beobachteten Unterschiede in den Ergebnissen von psychologischen Testen sorgfaltig sein muss. Um eine Verbesserung der Technik zu erzielen, schlagt der Autor vor, dass die beobachteten Unterschiede innerhalb eines Paares statistisch verwertet werden, und zwar nach Fehlerquellen der Messungen. Es gibt sich ferner, dass man erhaltene Unterschiede auch sorgfaltig erklaren muss In einigen Fallen hat der Autor bestandige Unterschiede unter den Geistesfahigkeiten eineiiger Zwillinge gefunden Wo solche Unterschiede gefunden wurden, scheinen sie nicht hinreichend erklart zu werden durch den auffalligen Typus der Umgebungsfaktoren, die gewohnlich in Betracht gezogen werden, statt dessen scheint die Verursachung solcher Unterschiede sehr komplex zu sein Die Ergebnisse zeigen, dass intensive Untersuchungen der Bedingungen der zugrunde liegenden Motivierung wichtige Ergebnisse aufweisen durfte

CARTER

THE VOCATIONAL ATTITUDES OF BOYS AND GIRLS OF HIGH-SCHOOL AGE*

From the Department of Psychology of Columbia University

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During the period of economic stress facing the entire world at the present time, greater attention than ever before is being given to the vocational guidance of adolescent boys and girls in the American high schools. It is quite necessary that both boys and girls be trained for and led into the vocations for which they are fitted if they are to be satisfied and happy in their future work, and if a better balance in the economic world is to be established Because of the present interest in this subject, a study of vocational attitudes of typical American boys and girls of the high-school age is both timely and important It is hoped that the study reported herewith will throw some light on a further understanding of this problem.

HISTORICAL SURVEY

A summary of studies and discussions of vocational interests may be divided into two parts, (*a*) theoretical studies and (*b*) experimental studies

a Theoretical Studies. Dewey (12), in a discussion of vocations, brings out that "the discovery of capacity and aptitude will be a constant process as long as growth continues One has discovered in himself, say, an interest, intellectual and social, in the things which have to do with engineering and has decided to make that his calling At most, this only blocks out in outline the field in which further growth is to be direct It is a sort of rough sketch map for use in direction of further activities"

Brill (8) has made the following statements concerning the problem of vocational selection "The average person seems to consider the selection of a vocation accidental or at least something that is

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[1]The senior author supervised the study reported in this paper, prepared the paper for publication, and supplemented the historical background, the junior author carried out the experiment and recorded the data

quite impersonal. He usually assumes that given certain qualifications, physical or mental, or both, a person could undertake any kind of work or vocation . . Investigation shows that the normal individual needs no advice or suggestion in the selection of a vocation, he usually senses best what activity to follow, and, what is more, he is invariably harmed if advice is thrust upon him by a person of authority. . . . When we ask a person why he follows a certain vocation he usually answers that he does not know, that he just drifted into it accidentally. Occasionally he answers that his grandfather and his father performed the same line of work and that he followed it. On applying the psychoanalytic method, however, one usually finds some hidden reasons for the particular activity. . The motives which actuate one to take up a certain vocation vary with the person, that is, every vocation is individually determined"

Green (16), in an analysis of the early choices of professions by children and adolescents, traces the theme of domination and display. As the child is dominated by the adults about him, he consequently comes to regard growing-up as the necessary preliminary to domination on his own account The child is most strongly attracted to the people he sees displaying themselves in dominating other people, animals, and big things L. S Hollingworth (19) found that adolescents of superior ability are keenly interested in the question of how they may find work which they can enjoy

b Experimental Studies As early as 1896, Earl Barnes (1, 2, 3) had started a comprehensive study of children's ambitions and attitudes toward future occupations. He concluded from his study that there is something permanently significant in children's ambitions, that girls' reasons for choice of vocation are hazy, that country children are far more concerned with their future work than are city children, and that class distinctions determine the child's attitude toward different types of work In his "Studies in Education," Barnes includes the researches of Young (28, 29) and Willard (26). The former, in her study of two groups of London children, found that, regardless of intelligence rating, the majority of girls wish to find work that offers more than mere industrial opportunity Willard's study of types of work selected revealed that at each age boys choose a far greater variety of vocations than girls

Several years later, in 1901, Wykoff (27) questioned children

of ages 5-16 years concerning their ambitions, and their reasons for these. The occupations listed were many and varied. Chambers' (10) study of children's ideals brought out the fact that girls are more philanthropic than boys. In so far as the boys' figures showed any definite tendency, it is toward an increase in altruistic motives with increase in age. An interesting point made by Brandell (7) in his study of children's ideals was that Swedish children place intellectual and artistic qualities higher than do English, Prussian, and Armenian children. In selecting their ideals and the people they would like to resemble, they do not consider money, social position, honor, and fame.

Poull (23) made a study of the relationship between intelligence and the child's choice of vocation in the case of 658 girls and 548 boys of the working class in New York City. She found that in any occupation or group of similar occupations a large range of intelligence levels existed which indicated that the child's interest, rather than his intelligence, was responsible for determining his choice of vocation. Such occupations as automobile mechanic, engineer, electrician, doctor, actor, chauffeur, and artist were most often chosen by the boys, while dressmaker, actress, stenographer, teacher, artist, bookkeeper, and secretary were selected by the girls.

To determine the permanency of interests, Poull checked up on the questionnaires from one to six months later. She found that in the case of the first and second choices of occupation 66.7% of persistent choices occurred in both instances, while in the third choice the persistence was found in only 33.3% of the cases.

Occupational interests of pre-high-school children were studied by Terman (25) in the case of a group of gifted children and a group of average children selected as a control. The gifted children showed a greater preference for such occupations as public service, professional careers (especially the boys), artistic, semi-professional, and agriculture (slightly). In the control group, the greater preference was for mechanical, transportation, athletic, and clerical work. In commercial occupations and social work, the two groups showed little difference in preference.

In the choice of occupations, gifted boys selected occupations which had the intellectual difficulties of such work as high-school teaching, industrial chemistry, or preaching, while the boys in the control group selected occupations demanding the intellectual status of a nurse, chef, or landscape gardener.

When the occupational ideals of the children were studied in comparison with the occupations of the parents, there was found to be less distance between the occupational ambitions of the child and the occupational status of the father than was true of children of the control group where the occupational ambitions were extravagant in comparison to the intelligence level of the children The only sex difference worthy of note was that the occupational ambitions of gifted boys rated somewhat higher than those of gifted girls.

Beeson and Tope (5) were interested in discovering to what extent high-school pupils have made vocational choices, to what extent these followed the occupations of the parents, and what high-school influences have been most powerful in determining their preferences. Two thousand high-school students indicated their preferences on a questionnaire. The first five preferences for the boys were as follows.

Engineering	25 %
(Undecided)	(19 %)
Agriculture	16 %
Mechanics	7 %
Salesmanship	6 %
Medicine and dentistry	5.7%

For girls the first five preferences were entirely different from those for the boys. They were as follows·

Teaching	21.6%
Clerical	21.4%
Nursing	12.8%
(Undecided)	(12.3%)
Music	6.6%
Commercial art	4.2%

In determining the influences responsible for these choices, the authors found that that of the parents was most important in the case of both boys and girls. The second and third factors of importance in determining the selection, especially in the case of the girls, proved to be the teacher

Bedford (4), in a study of the vocational interests of 1211 rural high-school students, found that professions were selected by the largest percentage of the group, 42.4%, followed by clerical occupations, 17.8%, manufacturing and mechanical industry, 10.0%,

and trade, 8 8% Only 58% of the 88% of the students who had definitely chosen a vocation professed to know the preparation required for it. The reasons given for the choice were interest in the work, belief in personal qualifications, advice of parents, teachers, and friends, and success of others. In most instances, the favorite school subject or recreational interest was found to be definitely related to the vocation chosen

Schiller (24) distributed questionnaires concerning vocational interests to 2026 elementary children in three different environmental districts in New York City "c environment," a poor district made up of unskilled, semi-skilled, and skilled laborers, "b environment," a district of business and professional men, and "a environment," a district of more highly educated business and professional men Such questions as "what do you want to be when you grow up?" "do you know anybody who is that?" and "if you can't be that, what do you want to be instead?" were asked.

The findings from this study were very interesting. The boys of the "c environment" showed a preference for the semi-skilled, skilled, and unskilled forms of work, while those in the "a" and "b environments" preferred work that can be classified as professional or business owning and managing. Girls in the "a" and "b environments" likewise showed a preference for professional vocations, while those in the "c environment" preferred a variety of skilled laboring positions.

Increase in age brought about fluctuations in vocational preferences In the case of boys, civil and military service declined in attractiveness, while interest in professional vocations increased with age In all of the environments, increase in age brought about an increase in interest in clerk and sales vocations for the girls, and a decrease in interest in teaching, especially among the girls of the "a" and "c environments." In the "a" and "b environments," both boys and girls showed a preference for the father's vocational classification, while in the case of the children of the "c environment" the father's vocation was the child's second choice.

Intelligence proved to have a pronounced influence on the choice of vocations As intelligence decreased, interest in the professions decreased and interest in skilled labor increased. Friends and neighbors were found to be most influential in the child's choice of vocation, while celebrities were the least influential Parents increase in influence as the environment improves

How permanent a child's vocational interests are has been studied by Franklin (13) in the case of 1600 high-school students. An original questionnaire, followed by three successive questionnaires, the last of which was given a year after the first, show a permanence of interests ranging from 45 to 67% for the boys and 64 to 75% for the girls. The activities of the child's summer vacation tended more toward fixating than toward changing the child's interests

Holmes (20) studied 300 Negro children living in the Harlem district of New York City to determine their vocational interests These children had a median age of 13 years He found that over half of the boys planned to enter the professions, while almost none intended to be unskilled laborers.

In a study of the occupational interests of 1200 children between the ages of 8 and 18 years in Soviet Russia, Borisov (6) found that 43% of the older boys and 20% of the younger boys wanted to be technicians. Girls showed a greater interest in teaching and in literary occupations The occupations of the parents proved to be more influential in the young child's choice than in the case of the older children. Active children showed a preference for active occupations, while slow children generally selected their parents' occupations and had a smaller range of choices This was true also of children of less ability.

One hundred and sixty-nine elementary-school children were questioned by Busemann (9) about their choice of future occupation. Of this number only 18 chose their fathers' professions, while 29 chose professions of a distinctly higher social status than that of their fathers. The size of the family from which the child came seemed to influence his choice of profession. Of those choosing the higher-ranking professions, 56% came from families with more than two children, as contrasted with 22% of those choosing their fathers' professions The presence of brothers and sisters thus seemed to act as an incentive to ambition

Lehman and Witty (21) found that with the onset of pubescence a marked change in vocational attitudes takes place, especially toward certain lines of work. It is difficult to show that the onset of pubescence is a cause of the modified attitude. The maturation of vocational attitudes is undoubtedly influenced by the attitudes of adults who live in the communities studied Clark and Withers

(11), from their survey of vocational attitudes, have shown that occupational interests are largely determined by the general social environment, and that our policy of occupational guidance must be built to a large extent upon general social and economic needs.

Purpose of Experiment

In making this study, the following points were considered

1 Does race or environment affect the child's choice of vocation?

2. What dominant motives prompt the choice?

3 Does the child reason about his aptitude for the vocation chosen, or his ability to attain his desire?

4 If he feels that he is not able to attain his choice of vocation, what reason does he give for this inability?

5 To what extent are parents interested in the child's choice?

6 If the parent does not agree with the child's selection, what reason is given for the difference?

7. Does a boy choose the same vocation as that followed by his parent?

Method

This study was carried out by the use of the following questionnaire, given, without comment, to the pupils of various schools

Questionnaire

1. What vocation or profession would you like most to follow? Give reason for your choice.

2 What vocation or profession are you most likely to follow? Explain why you expect to follow it

3 What vocation or profession do your parents want you to follow? Why?

Name, age, father's vocation and mother's vocation

The teacher was requested to rate each pupil's scholastic ability by the use of the grades excellent, good, fair, and poor. Excellent was considered above average, good and fair, average; and poor, below average It should be noted that in question 2, part 2, in practically every case, the pupil explained why he could not follow his first choice.

Subjects

Table 1 gives the number and type of pupils considered, the ages from 14 to 16 years, inclusive The types are representative of

American school children All the American children are in Kentucky schools, and those of foreign parentage are in New York City schools.

TABLE 1

TYPES AND NUMBERS OF BOYS AND GIRLS INCLUDED IN STUDY OF VOCATIONAL ATTITUDES

Ages 14 - 18

	Boys		
Negro			236
White	Technical	(middle social class)	60
	Technical	(foreign parentage)	44
	Academic	(upper and middle social class)	43
	Academic	(foreign parentage)	32
	Country		32
		Total	447
	Girls		
Negro			359
White	Academic	(upper social class)	105
	Academic	(middle and lower social class)	102
	Academic	(foreign parentage)	41
	Country		43
	Trade		35
		Total	685
		Grand total	1132

Results

The boys' choices of vocations, listed in Table 2, are worked out on a percentage basis for each group When the results are averaged, engineering rates as the highest choice of all the boys, but is first only with technical students of American parentage and academic students of foreign parentage With technical students of foreign parentage, aviation stands first and engineering second. Hattie Willard (26) found that foremost with boys is engineering, which leads at 10, 12, 13, and 16 years, and that in almost every instance this choice is made independently of the parent's occupation. Attention is called to a few outstanding exceptions in selections The high percentage of country boys who chose athletics (teaching, coaching, or professional play) is perhaps explained by the emphasis on that phase of extra-curriculum activities

However, it is encouraging to find the next highest choice is that of farming. The great interest in aviation evinced by the foreign technical students is due to that line's captivation of the imagination. Clark and Withers (11) show that there are waves of occupational

interest and that the so-called interest in probably in large measure a reflection of the dominant social situation With the exception of the Negro boys, aviation holds the interest of many because it appeals to the love of adventure. Travel and adventure were mentioned in two cases only by the Negroes, who stressed security and altruism in their reasons of choice The great number of Negroes who chose teaching is rather surprising until the reasons are considered. These are a desire to advance themselves socially and to get good pay for easier and cleaner work than that of their parents.

Civil service comes next, because of security, pay, and social standing Clark and Withers (11) found that the people in all the countries studied are interested in the more lucrative occupations or those which have social prestige and pleasant working conditions Undertaking was chosen by the Negroes only. Music was selected almost entirely by foreign and colored boys, and was the choice of only one American white boy. In this selection, heredity and background play a large part Quite as naturally, the American academic student chose business first and then the professions. The only students who failed to make a choice were of the academic schools

In the same way the girls' selections are studied in Table 3. These results, averaged, put teaching first because of the high percentage of country and Negro girls who made this choice. Teaching leads at every age except 13 and 14 according to Willard's results (26). Commercial work was selected by the greatest number of academic and trade-school students as the result of training offered in the school attended. Nursing was second highest among country girls, but had little appeal for the others. Of the enormous percentage of Negro girls who want to teach, 81 63% of them express the expectation of realizing their ambition, although only a small number will be able to do so This state of affairs indicates a need for guidance into other fields, as well as for an honest appraisal of ability. This serves to illustrate the statement of Clark and Withers (11) that occupational guidance must be built to a substantial degree upon general social and economic needs Many Negro girls selected teaching for the same reasons as the boys, with the additional motive of love of children Green (16) discredits the altruistic motive in the selection of teaching by saying that the desire to become a teacher, like "playing school," is no more than

TABLE 2

VOCATIONS IN THE ORDER OF THEIR SELECTION BY BOYS AND A COMPARISON OF CHOICES OF EACH GROUP BY MEANS OF PERCENTAGES BASED ON THE TOTAL NUMBER IN THE GROUP

	Negro	Technical (middle social class)	Technical (foreign parentage)	Academic (upper and middle social class)	Academic (foreign parentage)	Country
No of boys questioned	236	60	44	43	32	32
	%	%	%	%	%	%
Engineer	3 98	26 66	27 27	11 62	25	9 37
Teacher	22 12	3 03	4 54		6 25	3 12
Business	5 75	8 33		16 27	3 12	6 25
Civil service	14 6	1 66			3 12	3 12
Aviator	2 65	10 0	43.18	6.99	12 5	12 5
Doctor	6 63	3 03		13 95	9 37	6 25
Machinist	10 16	5 0	9 09		6 25	9 37
Musician	7 52		2 27	2.32	9 37	
Scientist	5 3	6 66		6.99	3 12	
Lawyer	4.42	5 0		11 62		3 12
Professional athlete or coach	3 98					18 75
Architect	2 21	5 0	4 54			
Carpenter	3 09		4 54		3 12	
Artist		6.66		2 32	6 25	
Writer	1 32			9.3	3 12	3 12
Printer	88	13 33				
Undertaker	3 53					
Farmer				2 32		15 62
No choice				6 99	3.12	

an expression of the wish to dominate others The selection of teaching by both sexes of the Negro race shows a striving for better things and brings out the fact that the field of intellectual vocations is limited for them. As would be expected, academic girls of the upper social types are the only ones who made no choice of vocation. Music was selected by the foreign and Negro groups because of their inherent love of it, and by the upper social group largely because of their cultural opportunities

All the reasons for selections have been calculated irrespective of the class of students, as it was found, when comparing groups, that

TABLE 3

VOCATIONS IN THE ORDER OF THEIR SELECTION BY GIRLS AND A COMPARISON OF CHOICES OF EACH GROUP BY MEANS OF PERCENTAGES BASED ON THE TOTAL NUMBER IN EACH GROUP

	Negro	Academic (upper social class)	Academic (middle and lower social class)	Academic (foreign parentage)	Country	Trade
No of girls questioned	359	105	102	41	43	35
	%	%	%	%	%	%
Teacher	66 01	17 14	14 7	19 51	32 55	2 85
Business woman	9 19	22 85	32 35	29 26	23 25	74 28
Nurse	6 96	95	12 74	7 31	27 9	5 71
Domestic worker (seamstress)	7 24					
Writer	83	14 28	3 92	9 75		8 57
Librarian	3 06	95	7 84		2 32	
No choice		21 9				
Musician	1.94	3 8	1 96	4 87		
Artist	83	1 9	3 92	21 95		
Actress	55	4 76	3 92	4 87		2 85
Scientist	27	2 85	4 09			
Missionary	27	95	1 96		4 65	
Social worker	55	1 9	98			
Interior decorator		1 9	2 94			
Doctor	.55		1 96			
Physical director			98		4 65	
Lawyer	27		2 94			
Beautician	55	95				2 85

there was very little difference in the type of reasons given The most important of these are listed in Table 4, and the number of times each reason occurred "Like it" comes first for both boys and girls "Fitted for it" is the second consideration with girls, money, with boys Altruism is third with girls, and "fitted for it" third with boys. "Fitted for it" includes the preparation for or some previous experience of the vocation While the students do not explain what they mean by "fitted for it," do these results indicate that girls consider their own abilities and aptitudes more in

their selections than do the boys? Willard (26) found money the most potent motive with boys at every age except 14 and 16, when "like it" governs, and with girls money holds second place. Their choice is influenced by "like it." Of the altruistic reasons, more than half are expressed by Negroes, who desire to help their race. According to Willard (26), the convent papers gave the highest showing of philanthropy, and the influence of religious training was very striking. This was also true of the Indian papers. The place of altruism with the girls coincides with Chambers' (10) statement that girls are much more philanthropic than boys.

The reasons that the pupils give for not following out the first choice are summarized in Table 5.

A comparison of the girls' and boys' reasons shows that "not possible to attain" stands first for both. This means in almost every case that the necessary training is impossible because of the expense and time involved. The fact that the student is preparing for another line of work, or will have opportunity to obtain other work, is second. This may be taken to mean that the pupil will have to get to work as soon as possible for economic reasons. A few mentioned that the second choice would lead to the first, or would enable them to work toward it. The parents' dictum plays a more important part with the girls.

A comparison of the attitudes of parents of all types of boys and of parents of all types of girls shows that 24.34% of the boys' parents offer no advice and 24.36% of the girls' parents. This

TABLE 4

REASONS GIVEN BY BOYS AND GIRLS FOR THEIR CHOICE OF VOCATIONS AND THE NUMBER OF TIMES EACH IS MENTIONED

Boys		Girls	
Like it	183	Like it	409
Money	92	Fitted for it	143
Fitted for it	58	Do good (54 colored)	79
Assured of position	31	Money	68
Offers advancement	24	No reason	18
Travel and adventure	22	Offers advancement	15
Do good (14 colored)	22	Travel and adventure	11
Choice of parent	9	Member of family in same work	5
Member of family in same work	6	Assured of position	3
No reason	0	Choice of parent	3

TABLE 5

REASONS FOR INABILITY TO FOLLOW FIRST CHOICE

Boys	%	Girls	%
Not possible to attain	49.14	Not possible to attain	47 85
Preparing for, or position assured	25 0	Preparing for, or position assured	31.42
Member of family in another line of work	11 2	Parents object	12 85
More money	9 48	More money	3 57
Parents object	4 31		

seems to prove that the modern parent is equally interested in both girl and boy.

To continue this consideration of parent attitude, it is found that 45 93% of all boys' parents agreed with their sons' choice, while 29.1% differed Fifty-six and eighty-five one-hundredths per cent of all girls' parents agreed, while 18 21% differed A study was made of the reasons for these differences of opinion, the most important of which will be found in Table 6

TABLE 6

REASONS FOR DIFFERENCE OF OPINION ON PART OF PARENTS

Boys	%	Girls	%
Make money	31 18	Thinks better fitted for another vocation	41.96
Thinks better fitted for another vocation	23 65	More money	16 96
Member of family in work of parent's choice	16.12	Better position for women	12 5
More secure	7 52	Unable to afford training	7 14
Altruistic reasons	4 3	More secure	5 53
Unable to afford training	1 07	Member of family in work of parent's choice	2 67

The parent is most concerned with his son's making a good living, and next with his aptitude for the type of work The girl's parent, on the other hand, placed fitness for work first, doubtless realizing the improbability of much financial success

When the boy's choice was compared with his father's work, well over three-fourths were not the same This is shown by the following figures· 98.24% of the American-born technical boys

did not choose the father's vocation; 95.83% of the academic boys of foreign parentage, 92.39% of the Negro boys; 88 88% of the country boys, 86 66% of the technical boys of foreign parentage, and 85 29% of American academic boys (white) According to Willard (26), the greatest number of those who choose the parent's occupation is found at 13, the age when so many boys leave school. From that age there is a steady increase in independent choice. Hollingworth (19) declares that scientific study of human nature informs us that about 75% of offspring can be assigned with social justice to the level of occupation for which they are fitted by simple reference to their parents' occupations. The remaining minority will be misfits in modern life if so assigned This study could not be made for the girls, as comparatively few of the mothers are employed in any work other than home-making.

A study of the teacher's rating, in relation to the child's choice, seems to prove that scholastic achievement has little bearing upon the selection of a vocation For example, out of the 54 boys who selected engineering, 9 were rated above average, 35 average, and 10 below average. Out of 36 boys who chose a business career, 26 were average, 4 below, and 6 above. Of 136 girls who made the same choice, 108 were average, 14 above average, and 14 below average. Forty-nine girls chose nursing, 31 of these were average, 7 above, and 11 below. An outstanding exception was in the case of the 8 boys who selected authorship, 5 of whom were above average and 3 average

SUMMARY

Briefly summarized, this study shows:

1. That engineering is first choice of vocation with boys, teaching with girls

2. That "like it" is the reason given by most of the boys and the girls. Money is second with boys, "fitted for it" with girls

3 That 63.39% of the boys and 77.22% of the girls expect to follow their first choice of vocation.

4 That the greatest number of both boys and girls gave as their reason for inability to follow their first choice "not possible to attain."

5. That the modern parent is equally interested in the vocation of both boy and girl.

6. That, when the parent disagreed with the son's choice, he gave as his reason that more money could be made in another field. With the girl the reason was that she was perhaps better fitted for another vocation.

7 That over three-fourths of the boys chose professions other than those of the parents

8 That scholastic achievement has little bearing on the adolescent's selection of a vocation.

Conclusion

In conclusion, this study of vocations selected by the different types found in American schools seems to prove that race and environment affect the student's selection For example, the Negro boys and girls chose teaching because, as a race, these people consider it a position that gives prestige Music was chosen only by those who had had opportunity to study, or whose heritage was the love of music. The interests and conditions of the times are also important as exemplified by the great number of boys who would like to be aviators and girls who prefer a commercial career. The majority of boys and girls do not consider their abilities or talents, or there would be a more equal distribution among the lines of work, and a greater number of boys would select the father's vocation or one similar A need for wise, careful guidance is made plain Not only must the child become acquainted with the many present-day occupations, but he must be shown how to evaluate his abilities and how to find his place in the economic structure

References

1 BARNES, E. Children's ideals *Ped Sem*, 1900, 7, 3-12

2. ——— Children's attitudes toward future occupations *Barnes' Stud Educ*, 1902, 2, 243-258

3 ——— Type studies in ideals *Barnes' Stud Educ*, 1902, 2, 36-40, 78-80, 115-120, 157-160, 198-200, 237-240, 277-280, 319-320, 359-360

4 BEDFORD, J H A study of vocational interests of California high school students based on a survey of twelve rural high schools *Calif Quar Sec Educ*, 1929, 5, 47-66

5 BEESON, M F, & TOPE, R E A study of vocational preferences of high school students *Voc. Guid Mag*, 1928, 7, 115-119

6. BORISOV, T P Ideals and interests of children as related to their neuropsychic peculiarities *Pedologia*, 1929, 3, 422-433

7. BRANDELL, G. Skolbarns personlighetsideal. *Svenskt arkiv f. ped.*, 1913, 1, 1-66. [Reported in (14).]
8. BRILL, A. A. Fundamental conceptions of psychoanalysis. New York: Harcourt, Brace; London: Allen & Unwin, 1922. Pp. x+336.
9. BUSEMANN, A. Berufswahl und Geschwisterzahl. *Zsch. f. pad. Psychol.*, 1930, 31, 559-564.
10. CHAMBERS, W. C. The evolution of ideals. *Ped. Sem.*, 1903, 10, 101-143.
11. CLARK, H. F., & WITHERS, W. The findings of a world study of the best distribution of people in occupations. *N. Y. Times*, 1931, Dec. 27.
12. DEWEY, J. Democracy and education: an introduction to the philosophy of education. New York: Macmillan, 1916. Pp. xii+434.
13. FRANKLIN, E. E. The permanence of the vocational interests of junior high school pupils. Baltimore, Md.: Warwick & York, 1924. Pp. viii+64. [Reported in (22, p. 424).]
14. GILBERTSON, A. N. A Swedish study of children's ideals. *Ped. Sem.*, 1913, 20, 100-106.
15. GODDARD, H. H. Ideals of a group of German children. *Ped. Sem.*, 1906, 13, 208-220.
16. GREEN, G. H. Psychoanalysis in the classroom. (2nd ed.) New York: Putnam, 1922. Pp. xi+272.
17. HILL, D. S. Comparative study of children's ideals. *Ped. Sem.*, 1911, 18, 219-231.
18. ——— Personification of ideals of urban children. *J. Soc. Psychol.*, 1930, 1, 379-392.
19. HOLLINGWORTH, L. S. Psychology of the adolescent. New York: Appleton; London: King, 1930. Pp. ix+259.
20. HOLMES, G. Unpublished study reported in (22, p. 423).
21. LEHMAN, H. C., & WITTY, P. A. A study of vocational attitudes in relation to pubescence. *Amer. J. Psychol.*, 1931, 43, 93-101.
22. MURPHY, G. Experimental social psychology. New York: Harper, 1931. Pp. 709.
23. POULL, L. E. Interests in relation to intelligence. *Ungraded*, 1922, 7, 145-158, 176-192, 200-222.
24. SCHILLER, B. An analysis of the vocational preference of 2,026 New York City elementary school children. M. A. thesis, Columbia Univ., 1929.
25. TERMAN, L. M., *et al.* Genetic studies of genius. Vol. 1. Mental and physical traits of a thousand gifted children. Stanford University, Calif.: Stanford Univ. Press, 1925. Pp. xv+648.
26. WILLARD, H. Children's ambitions. *Barnes' Stud. Educ.*, 1896, 1, 243-253.
27. WYKOFF, A. Children's ideals. *Ped. Sem.*, 1901, 8, 482-494.
28. YOUNG, S. A study in children's social environment. *Barnes' Stud. Educ.*, 1902, 2, 123-140.
29. ——— School girls' ideas of women's occupations. *Barnes' Stud. Educ.*, 1902, 2, 259-270.

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UNE ÉTUDE DE L'ATTITUDE DES GARÇONS ET DES FILLES DE L'ÉCOLE SECONDAIRE SUR LE CHOIX D'UNE CARRIÈRE

(Résume)

Un questionnaire sur l'attitude montrée à l'égard d'une carrière, soumis à 236 garçons nègres et à 211 garçons de race blanche, et à 359 filles nègres et à 326 filles de race blanche dans les écoles du Kentucky et celles de la ville de New-York, a révélé les faits suivants le génie est le premier choix de carrière des garçons tandis que l'enseignement en est le premier des filles, la raison le plus souvent donnée de ce choix de carriere est "je l'aime" au cas des garçons et des filles, tandis que la deuxième raison le plus fréquemment donnée du choix de carrière a été "l'argent" au cas des garçons et "capable de le remplir" au cas des filles; 63,39% des garçons et 77,22% des filles ont l'intention de suivre leur premier choix de carrière, tandis que ceux qui ne comptent pas suivre leur premier choix donnent comme la raison la plus fréquente le fait qu'il "n'est pas possible de l'atteindre", le parent moderne s'intéresse egalement à la carrière des garçons et des filles, l'intervention des parents dans le choix de carrière du fils a été basee sur la supposition que celui-ci pourrait gagner plus d'argent en choisissant une autre carrière, tandis qu'au cas des filles l'intervention a été du au fait que les parents croyaient que la fille serait mieux adaptée à une autre carrière qu'à celle qu'elle avait choisie, plus des trois quarts des garçons ne choisissent pas la carrière de leurs parents, enfin, le rendement scolaire n'influe que très peu sur le choix de carrière de l'adolescent

HURLOCK ET JANSING

EINE UNTERSUCHUNG DER EINSTELLUNG ZUM BERUF VON KNABEN UND MADCHEN IM MITTELSCHULALTER

(Referat)

Man unterbreitete einen Fragebogen uber die Einstellung zum Beruf 236 Neger- und 211 weissen Knaben, und 359 Neger- und 326 weissen Madchen in Schulen des Staates Kentucky und der Stadt New York, und erhielt die folgenden Ergebnisse Der Ingenieurberuf ist die erste Berufswahl der Knaben, der Lehrerberuf die erste der Madchen Der haufigste Grund, den Knaben und Madchen fur die Berufswahl angaben, war "mochte das gern," der zweithaufigste war "Geld" fur Knaben und "eigne mich dazu" fur Madchen. 63 39% der Knaben und 77 22% der Madchen hoffen, dass sich ihr erstgenannter Beruf verwirklichen werde, die ubrigen, die daran nicht glauben, geben als haufigsten Grund "Verwicklichung unmoglich" Moderne Elt rn interessieren sich fur die Berufswahl der Knaben sowohl, wie fur die der Madchen Der Einspruch der Eltern gegen die Berufswahl der Sohne beruht auf der Annahme, dass diese in andern Berufsarten mehr Geld verdienen konnen, gegen die Wahl der Madchen auf dem Glauben, dass sie sich fur einen andern Beruf als den gewahlten besser eignen Über drei Viertel der Knaben wahlten andere Berufe als die der Eltern Endlich, Schulleistungen haben wenig Einfluss auf die Berufswahl der Jugend

HURLOCK UND JANSING

A STUDY OF THE RELATION OF OCULAR AND MANUAL PREFERENCE TO MIRROR READING[*][1]

From the Wayne County Training School

SAMUEL A KIRK

In an attempt to trace the etiology of reading disabilities investigators have observed that retarded readers may be abnormally fluent in mirror reading and may exhibit a tendency to reverse letters and words, as in reading *b* for *d*, *p* for *q*, and *was* for *saw* These anomalies in reading have been explained by Orton (6) as resulting from the lack of cerebral dominance. He formulated the theory that children who have not established a clear-cut dominance of one cerebral hemisphere tend to reverse words and letters and to manifest great facility in mirror reading. Dearborn (1), on the other hand, does not accept the theory of cerebral dominance, but prefers to explain the fact of reversals among deficient readers in what he regards as the more objective terms of ocular and manual dominance. By comparing a group of extremely retarded readers with an unselected public-school population, Comfort (reported in 1, p. 704) found a preponderance of left-eyedness and mixed conditions of ocular and manual dominance in the group of retarded readers Dearborn therefore concluded. "The dextral sequence of eye movements is kinesthetically the essence of reading. Left-eyed children may tend to move in the opposite direction, to begin at the wrong end of words or to reverse the order or even to perceive letters in the wrong way as in seeing *b* as *d*, or *boy* as *dog*" Although he suggests a relationship of left-eyedness to reversal errors and to the tendency to read from right to left, Dearborn has not experimentally investigated these relationships, nor has he related these anomalies to facility in mirror reading

*Recommended by Thorleif G Hegge, accepted for publication by Carl Murchison of the Editorial Board, and received in the Editorial Office, May 5, 1933

[1]From the Wayne County Training School, Northville, Michigan, Robert H Haskell, M D., Medical Superintendent *Studies in Educational Disabilities and Mental Deficiency*, directed by Thorleif G Hegge, Ph D, Scientific Director The author is also indebted to Miss Elizabeth Sunday for aiding in the administration of the tests

Working independently of Dearborn, Marion Monroe investigated various phases of reading disabilities. In one of her first studies (4) she found that retarded readers were more fluent in mirror reading than were normal readers of the same reading grade. In a later study (5) she verified the results of the first experiment and also found a greater incidence of left-eyedness in a reading-defect group than among normal readers. Furthermore, she has attempted to test the belief that left-eyedness or mixed conditions of ocular and manual dominance may be significantly related to mirror reading. Since the present experiment is very similar to the study reported by Monroe, the latter will be described in some detail.

Using three consistent trials with a cardboard cone as the criterion of ocular dominance, and regarding the hand preferred for spontaneous writing as the dominant hand, Monroe (5) compared *children who presented consistent dextral eye-hand dominance with* children who showed preference for the right hand and the left eye. Her results showed that in a control group of normal readers (33 pure dextrals and 18 mixed dextrals)[2] the mixed dextrals made significantly fewer errors in mirror reading, but were not significantly superior in terms of time. In the reading-defect group (62 pure dextrals and 42 mixed dextrals), however, the mixed dextrals exhibited significantly greater facility than the pure dextrals in speed of mirror reading, but there was practically no difference between the two dextrality types in terms of errors. She concluded "Left-eyed preference is associated with fluent mirror-reading, and fluent mirror-reading is associated with reading disabilities." Monroe seemed to regard her findings as merely suggestive and pointed out that in order to disclose the nature of the obscure relationships between hand-and-eye preferences, mirror reading, and reading disabilities further controlled experimentation is needed.

The Problem

The present problem is to study, by means of more reliable tests, the relationship between ocular and manual preference and mirror reading in a group of high-grade mentally defective children.

[2]Dr Monroe defines pure dextrals as children who present consistent dextral preference, i e, right-hand-right-eye dominance, and mixed dextrals as children who present right-hand-left-eye dominance.

Method of Experimentation

A number of children were tested for ocular and manual preference and were then given normal- and mirror-reading tests.

a. Ocular preference was determined by giving ten trials on the Miles V-scope (3), and five trials on the sighting test used by Scheidemann (7). The criterion for eye preference was at least eight out of ten consistent responses on the Miles Test and at least three out of five consistent responses on the Scheidemann Test.

b Handedness was determined by giving four handedness tests, namely: (1) hand used for spontaneous writing, (2) batting, (3) needle-threading, and (4) tapping. The last consisted of a comparison of the right and left hands in terms of the number of taps within a 10-second period (two trials for each hand) The criterion for handedness was the hand preferred for spontaneous writing plus a correspondence of two out of the three other handedness tests given.

c. Mirror-reading tests Two mirror-reading tests were given First, the mirror-reading test used and standardized by Monroe (5, p. 197) was administered according to directions This test requires the child to read a selection of 46 words of primer material from a mirror. It is the observation of the writer and others that certain children experience difficulty in adjusting to the position of the primer and the mirror, and frequently refuse to try For this reason another mirror-reading test was devised and used together with that of Monroe This second mirror-reading test consisted of Gray's Oral Reading Check Tests (2), Set I, Numbers 3 and 5, reprinted in mirrored form so that the child would not be required to read from a mirror. These check tests as standardized by Gray are equivalent, each consisting of 40 words of primer or first-grade reading material Moreover, to provide for comparison with normal reading of equivalent material, the Gray Oral Reading Check Tests, Set I, Numbers 2 and 4, were administered in standard form. Thus each subject was required to read, in order, the following material: standard Check Test 2, mirrored Check Test 3, standard Check Test 4, and mirrored Check Test 5 For convenience mirrored Check Tests Numbers 3 and 5 will hereafter be referred to simply as "the mirrored check test."

Whereas in the Monroe mirror-reading test no aid is given when

a child blocks on a word, on the mirrored check test the directions provided for aiding a subject after he had blocked on a word for ten seconds The time for reading each paragraph was taken by means of a stop-watch and all errors were recorded. The following were regarded as errors words aided, words omitted, words inserted, words mispronounced, and two or more consecutive words repeated.

d *A grade score* for each child was obtained by giving the Gray Standardized Oral Reading Paragraphs A further measure of oral reading in terms of time and errors was obtained by giving each child the Gray Oral Reading Check Tests, Set I, Numbers 2 and 4, as described above.

e. *Selection of Subjects* The subjects were high-grade mentally deficient children in the lower division of the Wayne County Training School In order to obtain a sufficient number of left-eyed subjects a teacher informally tested the eye preferences of children in the classroom, and those suspected of being left-eyed were referred for the examination. Other children were selected at random on the basis of the teacher's judgment that their reading ability was between Grades 1 and 4 All subjects were tested individually on the battery of tests listed above.

Seventy-four subjects participated in this experiment The records of 13 subjects were discarded either because handedness or eyedness could not be determined according to the criteria given above, or because they scored lower than Grade 1 4 or above Grade 4.0 on the Gray Standardized Oral Reading Paragraphs Thus the remaining subjects were either distinctly left- or right-eyed, and left- or right-handed according to the criteria previously set forth, and all subjects scored between Grade 1.4 and Grade 4 0 on the Gray Standardized Oral Reading Paragraphs

Results

The scores of 61 high-grade mentally defective children (median IQ 67; interquartile range 61-73) are given in the following tables It should be mentioned that the group was fairly homogeneous The interquartile range for CA's was 12-14 The interquartile range for MA's was 8-9 The group consisted of 30 girls and 31 boys

First, in order to test the prevalent belief that mirror reading is associated primarily with left-eyedness, a group of 30 right-eyed

subjects was compared with a group of 31 left-eyed subjects, irrespective of handedness. Both groups, however, were largely right-handed, there being 5 left-handed subjects in the right-eyed group and 6 left-handed subjects in the left-eyed group.

TABLE 1

A COMPARISON OF RIGHT-EYED AND LEFT-EYED GROUPS IN MIRROR READING

	Right-eyed group		Left-eyed group		Diff / PE$_{diff}$
	N	Mean	N	Mean	
Normal reading					
1. Gray Oral Reading Paragraphs					
Reading grade	30	2 69±0 09	31	2 79±0 07	85
2 Gray Oral Reading Check Tests (Set I, Nos 2 and 4)					
Time	30	52 66±3 86	31	52 54±3 53	02
Errors	30	3 47±0 45	31	3 13±0 34	60
Mirror reading					
1 Mirrored Check Test					
Time	30	122 66±4 64	31	148 65±8 17	2 77
Errors	30	19 93±1 35	31	19 39±1 29	.29
2 Monroe Mirror-Reading Test					
Time	28	92 21±4 54	28	88 46±4 76	57
Errors	28	12 28±0 90	28	11 64±0 85	52

From the data given in Table 1 it is readily seen that in terms of normal oral-reading ability the two groups are quite equivalent, both on the grade score as obtained by the Gray Oral Reading Paragraphs test and on the Gray Check Tests (Set I, Nos 2 and 4) The results of the scores obtained on the mirrored check test show that the left-eyed group is inferior in mirror reading in terms of time and slightly superior in terms of errors but that neither difference is statistically significant The scores on the Monroe mirror-reading test verify the results of the mirrored check test in that no significant difference is found between the right- and the left-eyed groups.

To test the reliability of the mirrored check test the reliability coefficient for time of mirror reading was obtained by correlating

mirrored check test 3 against mirrored check test 5. The correlation was found to be +.80±.03, and, when corrected for length by the Spearman-Brown "prophecy" formula, became +.89. For errors the reliability coefficient was +.77±.04, which, when corrected for length, became +.87. No reliability coefficient was obtained for the time on the Monroe mirror-reading test. The correlation of errors on the first half of the test with the errors on the second half of the test was +.53±.06. Correction for length gave a reliability of +.76. Thus both mirror-reading tests are sufficiently reliable to warrant their use as measures of ability in mirror reading.

TABLE 2

A COMPARISON OF HOMOLATERAL AND CONTRALATERAL EYE-HAND GROUPS IN MIRROR READING

	Homolateral eye-hand preference N	Homolateral eye-hand preference Mean	Contralateral eye-hand preference N	Contralateral eye-hand preference Mean	Diff. / P. E.$_{diff}$
Normal reading					
1 Gray Oral Reading Paragraphs					
Reading grade	31	2.71±0.08	28	2.77±0.08	.50
2 Gray Oral Reading Check Tests (Set I, Nos. 2 and 4)					
Time	31	55.61±3.97	28	49.50±3.56	1.15
Errors	31	3.32±0.38	28	3.36±0.45	.07
Mirror reading					
1 Mirrored Check Tests					
Time	31	130.35±5.31	28	133.57±6.84	.37
Errors	31	18.45±1.27	28	20.21±1.39	.94
*2 Monroe Mirror-Reading Test					
Time	30	99.00±4.57	25	79.68±4.55	2.99
Errors	30	11.70±0.87	25	12.48±0.91	.62

*The number of cases for the Monroe mirror-reading test were fewer than for the mirrored check test because a few of the subjects seemingly found reading from a mirror extremely awkward and after several futile attempts refused to continue. Their scores on the mirrored check test, however, were included. The insignificant tendency toward the superiority of the contralateral group on the Monroe mirror-reading test in terms of time is due to the fact that certain subjects who scored very high in time on the mirrored check test were eliminated from the scores of the Monroe mirror-reading test because they refused to continue. This fact explains the discrepancies in tendencies between the mirrored check test and the Monroe mirror-reading test.

A comparison of a group with homolateral eye-hand preference and a group with contralateral eye-hand preference is given in Table 2 This comparison is very similar to the comparison in Table 1 with the exception that the five left-handed subjects in the right-eyed group of Table 1 fall in the contralateral eye-hand group of Table 2, and, similarly, the six left-handed subjects in the left-eyed group of Table 1 fall in the homolateral eye-hand group of Table 2.

On the mirrored check test the contralateral eye-hand preference group is slightly slower in mirror reading and presents slightly more errors than the homolateral eye-hand preference group. In neither case are the differences statistically significant Although on the Monroe mirror-reading test the contralateral group exhibited greater facility in terms of time, it presented a greater number of errors than did the homolateral group. Neither difference is significant

Since Monroe's results are based on a comparison of a group which presented right-hand-right-eye preference (pure dextrals) with a group showing right-hand-left-eye preference (mixed dextrals), our results were analyzed for this handedness-eyedness classification. The data are presented in Table 3 Fewer cases fall in these handedness-eyedness categories since all left-handed children were necessarily eliminated from this comparison.

The results given in Table 3 indicate that the so-called condition of mixed dextrality does not facilitate mirror reading. The differences between the means of the mirrored check test tend, if anything, to indicate a superiority of the pure dextrals, in terms of both time and errors, whereas the differences between the means of time and errors on the Monroe mirror-reading test point to a superiority of the mixed dextrals[3] None of the differences, however, are statistically significant.

The data given in Tables 1, 2, and 3 indicate mainly that there is no relation between left-eyedness and mirror reading in our group. Although in Tables 1 and 2 there were an equally small number of left-handed subjects in each group, it should be emphasized that this study has dealt with groups having left- or right-eye preference associated largely with right-handedness. It should also be emphasized that not all possibilities of ocular and manual preference and their relation to mirror reading have been investigated. Further

[3]See footnote to Table 2

TABLE 3

A Comparison of Right-Handed-Right-Eyed and Right-Handed-Left-Eyed Groups in Mirror Reading

	Right-handed right-eyed group		Right-handed left-eyed group		
	N	Mean	N	Mean	$\frac{\text{Diff}}{\text{P.E}_{diff}}$
Normal reading					
1 Gray Oral Reading Paragraphs					
Reading grade	25	2 66±0 09	23	2 76±0 09	75
2 *Gray Oral Reading Check Tests* (Set I, Nos 2 and 4)					
Time	25	53 72±4 28	23	49 78±3 90	68
Errors	25	3 28±0 43	23	3.13±0.40	.25
Mirror reading					
1. Mirrored Check Test					
Time	25	122 68±5 29	23	135 95±8 08	1 37
Errors	25	19 16±1 45	23	19 43±1 50	18
2 Monroe Mirror-Reading Test					
Time	25	95 12±4 78	22	81 27±4 93	2 01
Errors	25	14 32±1.24	22	12 82±0 98	95

experimentation is necessary to disclose any possible relation of mirror reading to other conditions of ocular and manual preference, mainly sinistrality, ambidexterity, and amphiocularity

Supplementary Results

Our general results and conclusions immediately raise the question. Wherein did the present study differ from that of Monroe, and what is responsible for the difference in the results? At the present stage of experimentation this question cannot be answered conclusively, but a comparison of our data with those of Monroe suggests a tentative explanation based on the difference in the intelligence levels of the two groups

Since no normal children have been tested on the mirrored check test, no comparison of our group with normals could be made on these tests However, since Dr. Monroe has established norms for mirror reading with normal readers of normal intelligence, it was possible to compare our mentally defective group with Monroe's normal group on the Monroe mirror-reading test.

A comparison of the scores obtained by our subjects on the Monroe mirror-reading test with the norms standardized by Monroe is given in Table 4. The interquartile ranges for errors in our group are somewhat similar to the interquartile ranges of Monroe's normals. As would be expected from these similar distributions, 23 per cent of our mentally defective group fall in the highest quartile of Monroe's norms In terms of time, however, 84 per cent of our group fall in the highest quartile of Monroe's norms, i e., 84 per cent of our group exceed 75 per cent of the normals in fluency in mirror reading.

If our grade scores are comparable with those of Monroe, retarded intelligence may be one of the factors associated with facility in mirror reading Of course, our grade scores are obtained only on the Gray Oral Reading Paragraphs test, whereas Monroe's grade scores were obtained by taking the average of four reading tests. Although this point precludes the formulation of definite conclusions (since the scores obtained on the Gray Oral Reading Paragraphs test may not be sufficiently comparable with Monroe's grade scores), such a comparison does suggest that mentally retarded children may be superior mirror readers when compared with normals of the same reading grade This superiority may tend to eliminate the possible influence of ocular and manual preference in our group.

TABLE 4

A COMPARISON OF NORMAL AND MENTALLY DEFECTIVE CHILDREN IN MIRROR READING

	Grade	Monroe's* norms, interquartile range of normal readers (med IQ 110)	Interquartile range of 56 mentally defective children (*med* IQ 67)	Percentage of mentally defective *group* exceeding 75 per cent of normals in fluency in mirror reading
Time for reading passage	I	Inc. - 234″	134″-67″	100 per cent
	II	265″ - 122″	123″-58″	77 ″ ″
	III	210″ - 115″	107″-61″	83 ″ ″
				Average 84 ″ ″
Errors in reading passage	I	Inc -23	23-9	73 ″ ″
	II	21-7	16-6	24 ″ ″
	III	13-4	16-7	0 ″ ″
				Average 23 ″ ″

*(4, p 409)

Discussion

If left-eyedness and a condition of mixed ocular and manual preference (as studied in our group) are not factors influencing facility in mirror reading in a mentally defective population, what then would be the contributing factors? What essential characteristics are peculiar to the mirror reader? The writer has no further experimental facts to offer, but some suggestions may be given on the basis of clinical observations

In a group of mentally retarded reading cases, the writer has had the opportunity to study the characteristics of nine extreme mirror readers. No single consistent factor was found in the group. For example, three subjects were left-handed and left-eyed, three others were right-handed and left-eyed, and the remaining three were right-handed and right-eyed. All nine cases were examined by an expert ophthalmologist. He reported that five cases had a greater or less degree of muscle imbalance, either defects of convergence or opthalmoplegia externa. The other four were diagnosed as having refractive errors of various forms As to other characteristics, one left-handed subject suffered from right hemiplegia. Two subjects had speech impediments (lisping and stuttering). Thus it is apparent that mirror reading, in this group of nine extreme mirror readers, cannot be attributed to any one of the above-mentioned factors alone

Our findings seem to indicate that the relationships between mirror-reading ability and physical characteristics may be more complex than is generally appreciated and in all probability may also be obscured by the factor of intelligence

Moreover, the complexity of the problem is further emphasized by the possibility that environmental factors may also be instrumental in the development of facility in mirror reading. It is perhaps not sufficient to ascribe fluent mirror reading in an individual to some physical or psychophysical characteristic alone, for the characteristic may be considered only as a disposition to the acquisition of mirror reading It follows, therefore, that the acquisition of mirror reading, which is, of course, a learned response, may also be dependent upon the particular nature of the situation in which this response occurred.

We can, from observation and clinical practice, find many environmental factors which may be operating to confuse the child in the direction of reading. First, one may ask, what is the influence of

a right-handed teacher on a left-handed child or a left-handed teacher on a right-handed child? We do not know what conflicting tendencies may develop in a child whose handedness differs from that of the teacher. Secondly, to what extent are the present methods *of teaching instrumental in the development of mirror reading?* One may raise the question of the possible influence of the child's initial set in the direction of reading caused by certain teaching procedures. For example, a teacher may point to a sentence or a word from the right side, or the child, who is seated to the right in the classroom in relation to the blackboard and the reading charts, may first have his attention attracted to the wrong end of words and sentences. Moreover, many primers and picture dictionaries have some action pictures with motion indicated in the direction from right to left. Receiving no specific instructions at the outset, a beginning reader, who knows nothing of direction in reading, *may under such conditions develop a tendency to read from* right to left and thus lay the foundation for mirror-reading ability.

It should be pointed out, however, that these possibilities are only suggestions and that their significance in the development of fluent mirror reading is unknown and remains a problem for future experimentation.

Summary

A group of 61 high-grade mentally defective children (median IQ 67) were tested for ocular and manual preference and were given normal- and mirror-reading tests. (1) Contrary to previous *experimental results and to theoretical expectation the* 31 *children* in the left-eyed group (largely right-handed) were not superior mirror readers as compared with 30 right-eyed subjects of the same handedness classification and of the same reading grade. (2) A comparison of our results with those of Marion Monroe for normal children (median IQ 110) suggested that our mentally defective group were superior in mirror reading to normal children of the same reading grade. (3) It is suggested that certain environmental factors may be instrumental in the development of mirror reading, and that future investigations of the causes of this abnormality should include the study of environmental factors as well as of a combination of various physical, psychophysical, and environmental conditions.

References

1 Dearborn, W F Ocular and manual dominance in dyslexia. *Psychol. Bull*, 1931, **28**, 704

2 Gray, W. S Gray oral reading check tests Bloomington, Ill., Pub School Publ Co

3 Miles, W R The A-B-C vision test for ocular dominance Stanford University, Calif. Stanford Univ, Psychol. Laboratories, 1928.

4 Monroe, M Methods for diagnosis and treatment of cases of reading disability. *Genet Psychol. Monog*, 1928, **4**, 333-456

5 ———— Children who cannot read Chicago: Univ. Chicago Press, 1932 Pp. xvi+205.

6 Orton, S T Word blindness in school children. *Arch Neur & Psychiat*, 1925, **14**, 581-615.

7. Schcidemann, N. V A simple test for ocular dominance *Amer J. Psychol*, 1931, **43**, 126

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UNE ÉTUDE DE LA RELATION ENTRE LA PRÉFÉRENCE OCULAIRE ET MANUELLE ET LA LECTURE AU MIROIR

(Résumé)

On a testé un groupe de soixante et un enfants faibles d'esprit supérieurs (Q. I median 67) pour leur préférence oculaire et manuelle et on leur a fait subir des tests normaux et des tests de lecture au miroir (1) Contrairement aux résultats expérimentaux antérieurs et à l'expectation théorique les trente et un enfants du groupe de l'oeil gauche (dont la plupart ont été droitiers) ne sont pas montrés supérieurs à l'égard de la lecture au miroir aux trente sujets d'oeil droit de la même classification quant à l'usage des mains et du même rang à l'égard de la lecture (2) Une comparaison de nos resultats à ceux de Marion Monroe pour les enfants normaux (Q I médian 110) a suggéré que notre groupe d'enfants faibles d'esprit ont eté supérieurs dans la lecture au miroir aux enfants normaux du même grade de lecture (3) On suggère que certains facteurs du milieu puissent être en jeu dans le développement de la lecture au miroir, et que les enquêtes subséquentes doivent inclure l'étude des facteurs du milieu aussi bien qu'une combinaison de diverses conditions physiques, psychophysiques, et du milieu

Kirk

EINE UNTERSUCHUNG DER BEZIEHUNG DER GESICHTS- UND HANDTATIGKEIT ZUM LESEN IM SPIEGEL

(Referat)

Man prufte eine Gruppe von einundsechzig hochgradig geistig minderbegabten Kindern (mittlerer IQ, 67) auf ihre Gesichts- und Handbevorzugung

und gab ihnen normale Spiegellesetests (1) Im Gegensatz zu den fruheren Ergebnissen experimenteller Untersuchungen und theoretischen Erwartungen waren die einunddreissig Kinder der linksaugigen Gruppe (meistens rechtshandig) nicht uberlegene Spiegelleser, verglichen mit den dreissig rechtsaugigen und gleichhandigen Versuchspersonen mit gleicher Lesefertigkeit (2) Ein Vergleich unserer Ergebnisse mit denen Marion Monroes fur normale Kinder (mittlerer IQ, 110) drangt die Vermutung auf, dass unsere minderbegabte Gruppe den normalen Kindern mit gleicher Lesefertigkeit im *Spiegellesen uberlegen ist* (3) *Man darf annehmen, dass gewisse* Faktoren des Milieus in der Entwicklung des Spiegellesens behilflich seien und der Autor rat bei kunftigen Untersuchungen uber die Ursachen dieser Abnormalitat die Untersuchung sowohl der Milieufaktoren wie der Kombinationen verschiedener physischer, psychophysischer und milieuartiger Bedingungen einzubeziehen

KIRK

A SCALE FOR EVALUATING ADOLESCENT PERSONALITY*[1][2]

From the Department of Child Development and Parent Education of the New York State College for Teachers

MARGARET HAYES

The increasing emphasis upon the all-round development of the child has revealed a new measurement need in education. Teachers are expected to develop desirable social and emotional behavior patterns in children as well as mental and physical ones. Progress depends in large measure upon evaluation of work at various stages, in order that ineffective methods may be discarded and better procedures devised. Intelligence testing was accepted by many educators at the beginning of the twentieth century, and this was followed closely by the objective measurement of subject-matter. Definite accomplishments in aptitude testing came about 1918. This was followed by techniques for discovering interests, and later supplemented to evaluate attitudes and character or personality.

So far, none of the techniques for evaluating interests, attitudes, and character have been widely used in the schools. Koos (6, pp. 281-282) reports in a recent survey of junior, senior, and four-year high schools that ratings on character were used in not more than 10 per cent of these schools, whereas 61.9 per cent used standardized achievement tests, 50 per cent had physical examinations and meas-

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[2]This scale has been published by the Psychological Corporation, 522 Fifth Avenue, New York City, under the title "A Scale for Evaluating the School Behavior of Children Ten to Fifteen," and may be obtained from them in any desired quantity.

urements, and 75 per cent made at least some use of mental tests

Efforts to estimate character or personality have usually taken the form of rating scales and tests Sherman (7) has published an excellent résumé of the more important work that has been done in this field, together with an analysis of its probable value Perhaps the most ambitious and better-known efforts to test phases of personality are the Character Education Inquiry Tests devised by Hartshorne and May (2, 3, 4), the work of Wickman (11) in evaluating children's behavior and teachers' attitudes, Stodgill's (8) study of parental attitudes and mental hygiene standards, and Downey's (1) Will-Temperament Tests. These studies have given an impetus to efforts to evaluate personality and have doubtless had a strong influence upon present-day thinking along this line. However, the numerous difficulties in personality measurement have been only partially overcome by these authors. The Character Education Inquiry Tests seem impractical for general use because of their cost and the amount of time required to administer the tests and score the papers, according to Hayes (5) The works of Stodgill and Wickman have been criticized by Watson (10) for ambiguity of items, unreliability of judgments as shown by high standard deviations, and the possible fallacy of using the judgments of mental hygienists for a standard. Progress is being made in this field by a gradual evolution of more accurate notions of the true nature of character or personality and closer approaches to accuracy and objectivity in its evaluation This paper describes a personality rating scale for use with adolescents. An attempt has been made to devise a procedure that is simple enough for the use of the average classroom teacher, not too time-consuming, and as objective as possible

There are many definitions of personality. Some of these seem quite different, but many of them contain elements upon which there is more or less general agreement. There is a pronounced tendency to regard social adjustments as related to personality The method of evaluating personality described in this paper is based upon a concept of personality as the complete set of habits or behavior patterns possessed by the individual, as these habits manifest themselves in the situations of everyday life Observable behavior is accompanied by inner tendencies or attitudes which must be taken into account in evaluating the observable behavior of individuals This

concept of personality is apparently in agreement with that of Voelker (9). In evaluating personality, the practical thing to do is to record overt behavior and make the best interpretation possible of the feelings and attitudes back of such behavior. Since any overt behavior must be interpreted in relation to the situation in which it manifests itself, any individual's possession of a given habit cannot be decided by its appearance in a single isolated situation. If, however, the individual's behavior is noted in several situations, a characteristic behavior pattern may be detected, both as to type of habit and degree of intensity In the scale which is described in this paper, the words "usually" and "often" are used to indicate the presence of a characteristic behavior pattern

The technique here described is called the "Personality Rating Scale for the Adolescent in the School" and is designed primarily for the use of teachers A similar scale is called the "Personality Rating Scale for the Adolescent in the Home" and is for the use of parents Their purpose is to show objectively the habit patterns of adolescents in terms of desirable or undesirable personality development and to furnish the basis for an analysis of the maladjustments and developmental needs of adolescents. By the use of these scales, it is possible to secure an objective score to represent the personality of the child and to secure diagnostic material necessary in meeting his needs

Construction of the Scale

The Personality Rating Scale for the Adolescent in the School, in its final form, is made up of a list of 100 items, each of which is a habit pattern which may be possessed by an adolescent In order to secure the items the author took 200 detailed one-hour diary records of the observable behavior in school of 20 adolescents An analysis of these records furnished 221 items which were submitted to a group of 100 students of advanced psychology in winter courses at City College, New York (Group A) to be evaluated according to the directions given below.

On the following pages are listed units of children's behavior These units vary in their significance as indications of character or personality development. Please evaluate each unit as follows

Assume that each statement tells one thing known to be true of a twelve-year-old boy or girl Place before each statement one number from the following:

—3 means	Sign of seriously defective character or personality; very bad
—2 means	Sign of defective character or personality, bad
—1 means	Sign of slightly defective character or personality; more undesirable than desirable
0 means.	No clear significance for character or personality; non-moral
+1 means	Sign of slightly desirable character or personality; *more good than bad*
+2 means:	Sign of good character or personality, definitely desirable
+3 means:	Sign of excellent character or personality, very markedly superior
? means	Ambiguous, might be good in some cases, bad in others

The same material was then evaluated according to the same directions by an especially selected group of twelve experts in the fields of education and psychiatry (Group B).

The 221 items were cut down to 135 by eliminating on four bases. First, all items that were questioned by 20 per cent or more of the judges in Group A as being ambiguous were dropped Then *all items whose mean value was between +.6 and —.6 according* to the evaluations of Group A were thrown out as being of little value one way or the other Also, all items for which the mean value was less than 4 times the standard deviation of the mean were eliminated as indicating too much scatter in the values assigned by the judges in Group A Finally, it was decided that the scale could be shortened by removing one of each set of several items which were opposites For example, the original list contained the following two items, the second of which was dropped:

This child usually tells the truth
This child often tells untruths

The items were grouped under eight headings to make the scale more useful for diagnostic purposes. The headings were chosen from a situational viewpoint, with a view to locating pupil problems more specifically Table 1 gives the 100 items finally selected for the school scale, arranged in situational groups, with the means and percentages of questions for both groups of judges, and the standard deviations for Group A The values used for scoring the scale are taken from Group A because these values were based on a large

number of judgments. The data obtained from Group B were used only for comparative purposes.

It may be interesting at this point to study the evaluation of these items more closely, in order to understand better the attitudes of the two groups of judges toward the various behavior habits. It will be noted from Table 1 that the differences in values assigned are in degree, not in kind, in no case do the two groups of judges disagree in assigning either a negative or a positive value to an item.

The items for which the values of the two groups of judges are identical are: 98, 96, 89, 87, 82, 78, 68, 54, 26, 15, 12, 11. On 13 the values differ by .6 or more. The two groups differ on items 5, 8, 23, 24, 25, 47, 65, and 71 by .6, on item 97 by .7, on items 22 and 74 by .8, on item 27 by 9, and on item 56 by 1 3 Of the last four items which represent points of greatest difference of opinion, three are habits which indicate emotional instability or a withdrawing from the solution of the problem and are considered more undesirable by the experts than by the teachers. Agreement in the values obtained from the two groups of judges is evidenced by the correlation of .95 between the mean values for Groups A and B obtained by the rank-difference method.

Directions for Rating

The directions for rating a pupil are as follows:

Following is a list of habits which children 10 to 15 years old have been found to show. No one child could have all the habits listed, but is certain to have a considerable number of them

Draw a circle around the *T*, *F*, or *U* before each item to indicate *T* you believe the statement is true of the child being rated, *F* you believe the statement is not true of the child being rated, *U* you are uncertain whether the statement is true or not true of the child being rated. Be sure to draw a circle about *one* letter and *one only* for every item in the list.

Two samples are given below:

T F U usually accepts responsibility when the occasion arises.

T F U often wastes time.

Scoring

The scoring was provided for by arranging a score sheet with the mean values of the judgments of Group A as given in Table 1.

Decimal points were omitted in order to make the scoring easier. A child's score for the whole scale or for each of the eight situational groups was found by taking the algebraic sum of the values of the items marked true by the rater.

TABLE I

PERSONALITY RATING SCALE FOR THE ADOLESCENT IN THE SCHOOL

	Item	Group A Mean	Group A S. D.	Group A % ?	Group B Mean	Group B % ?
	I Relation to others generally					
1	Often does little things to make others happy	+2.4	.70	1	+2.0	0
2	Usually thinks of consequences both to self and others	+2.2	.80	4	+2.3	0
3	Usually accepts responsibility when the occasion arises	+2.2	.65	0	+2.4	0
4	Often shares with others	+2.1	.73	1	+1.8	0
5	*Usually does his share in any* group activity	+2.0	.65	0	+2.6	0
6	Often plays "hookey" from school	—1.9	1.08	9	—2.3	10
7	Usually does the work expected of him	+1.7	.69	7	+2.0	0
8	Usually defends his friends only *when they are in the right*	+1.7	1.33	11	+2.3	10
9	Usually makes friends easily	+1.7	.82	8	+2.1	10
10	Often starts fights	—1.7	.81	3	—1.8	0
11	Usually quickly forgives wrongs done to him	+1.6	.94	4	+1.6	0
12	Often uses vulgar or profane words	—1.4	1.03	1	—1.4	0
13	Usually eats lunch with a group	+1.3	.76	7	+1.6	0
14	Often brings flowers or other decorative objects for the schoolroom	+1.3	.91	7	+ .9	10
15	Often fights when attacked by others	+1.3	.92	6	+1.3	10
16	Is usually on time	+1.3	.79	0	+1.5	0
17	Usually comes in or goes out of classroom with group which is making unnecessary noise. Takes part in disturbance	—1.3	.77	7	—1.5	0
18	Often quarrels with others	—1.3	1.05	5	—1.7	10
19	*Usually* comes *in* or *goes* out of classroom with group talking and laughing and taking part *in talking and laughing.* No unnecessary noise	+1.2	.97	16	+1.3	10
20	Often makes disturbing noises	—1.2	.71	7	—1.4	0

Item	Group A Mean	S. D	% ?	Group B Mean	% ?
21 Usually chooses friends because of their wealth or social standing	—1.1	94	19	—1.6	10
22 Often pretends to know more than he really does, or to have something that he does not have	—1.1	97	8	—1.9	0
23 Often offers comments voluntarily when the majority of the class are commenting freely	+1 0	.87	4	+1.6	10
24 Often complains about school conditions	— 9	79	18	—1 5	0
25 Usually defends his friends, whether they are right or wrong	+ .8	1.50	11	+ 2	10
26 Often chews gum or other objects during class	— 8	87	8	— .8	0
27 Often allows other people to impose on him without becoming angry	— .7	1.19	12	—1.6	20
28 Often boasts of accomplishments that he really has	— 6	86	11	—1 1	0
II Respect for rights of others					
29 Often steals	—2 5	.94	0	—2.3	0
30 Often cheats	—2 5	80	5	—2 4	0
31 Usually pays close attention while other pupils recite	+2 1	94	1	+1 7	0
32 Usually tells the truth	+1 8	73	1	+1.9	0
33 Usually cleans up and puts away school materials voluntarily	+1 8	1.05	0	+2.2	0
34 Usually becomes angry when he cannot do what he wishes	—1.7	1 00	8	—2.1	0
35 Often makes critical remarks about other children	—1 5	96	4	—2 0	0
36 Often laughs when another pupil makes a mistake	—1 1	85	8	—1.0	0
III Relation to teacher					
37 Is usually courteous to teacher and other adults	+1 7	68	1	+2.0	0
38 Often starts a whispered conversation during class period about something other than the lesson	—1.4	90	3	—1 5	0
39 Often eagerly performs small tasks at request of teacher	+1 3	.80	9	+1.0	0
40 Often asks teacher unnecessary questions about the assignment	—1 1	.64	7	—1.5	0
41 Often joins in whispered conversation during class period					

Item	Group A Mean	S D	% ?	Group B Mean	% ?
about something other than the lesson	—1 0	71	6	—1 2	0
42 Often shows his work to the teacher of own accord	+ 9	1 09	13	+ 6	10
IV Relation to other pupils					
43 Is usually courteous to other children	+2 1	64	1	+2 4	0
44 Often neglects his own work to do the work of others	—2 1	.66	13	—2 0	11
45 Often annoys other children by pulling at them, pinching and so forth	—1 6	94	1	—1 4	0
46 Usually comes in or goes out of classroom alone	—1 5	91	5	—1 8	0
47 Often tells on other pupils	—1 5	92	9	—2 1	0
48 Often looks on another pupil's paper while both are doing a class assignment	—1 5	1 08	11	—2 0	10
49 Often smiles when humorous passage is read in class	+1 4	80	5	+1 5	0
50 Often starts a conversation with another pupil during free period	+1 2	1.01	12	+1.3	0
51 Often makes "smart" remarks to other pupils during class	—1 2	91	12	—1.6	0
52 Often smiles at other pupils first in school	+1 1	1.07	19	+1 4	30
53 *Often smiles in response to* smiles of other pupils	+1 1	73	9	+ 8	0
54 Often talks with another pupil during free period (conversation started by another pupil)	+1 0	.67	9	+1 0	10
55 Often borrows objects from other pupils	— 8	75	5	—1.0	0
56 Usually definitely avoids the other sex	— 7	1 07	19	—2 0	10
V Initiative					
57 Often does a piece of original, creative work of own accord	+2 7	57	1	+2 9	0
58 Usually tries to solve own problems and not escape them	+2 6	57	0	+3 0	0
59 Has organized or helped to organize school club during the past year	+2 5	69	3	+2 0	10
60 Often undertakes extra projects voluntarily	+2 4	62	1	+2 3	0
61 Often starts activities in which others join	+2 2	76	4	+2 5	0

Item	Group A Mean	S D	% ?	Group B Mean	% ?
62 Often asks questions showing interest when majority of the class are not asking questions	+2 1	87	9	+1 9	10
63 Often holds office in school clubs	+2 1	62	4	+1 8	10
64 Leads in sports (heads team or holds office in athletic organization)	+2 0	86	12	+1 5	20
65 Often offers comments voluntarily when the majority of the class are not commenting	+1.7	1.13	12	+2 3	40
66 Usually goes ahead after the first suggestion	+1.7	1 03	5	+2 1	0
67 Often initiates pleasant surprises for the teacher	+1 7	1 06	9	+1 2	10
68 Usually finds own materials instead of asking teacher	+1 7	80	4	+1 7	0
69 Often leads the conversation in a free group	+1.5	85	16	+1 7	10
70 Often asks questions showing interest when the majority of the class are also asking questions	+1 4	.70	8	+1.5	0
71 Often holds up hand in response to a question of the teacher when he does not know the answer	—1.2	.98	4	—1 8	0
VI Health habits					
72 Is usually happy	+1 9	91	1	+2 4	0
73 Usually dresses neatly and keeps himself clean	+1 8	.80	0	+1 4	0
74 Often becomes easily upset	—1 5	1 14	6	—2 3	0
75 Often bites fingers or fingernails, rubs eyes, picks at fingernails, taps pencil on desk, drums on desk, or taps feet rhythmically on floor	—1 3	88	9	—1 5	0
76 Often puts feet on seat during class	—1 0	.92	7	— .7	10
77 Often changes from feeling happy to feeling unhappy	— .7	95	16	—1 1	0
78 Often yawns during recitation	— 7	.69	18	— 7	10
79 Often sits in a slouched position during class	— 7	74	6	— 6	0
VII General interests					
80 Often reads good books in free time in school	+2 1	76	3	+2 3	0
81 Usually takes an active part in club activities in school	+2 1	69	4	+1.7	0

Item	Group A Mean	S. D	% ?	Group B Mean	% ?
82 Often does a piece of creative work guided by another person	+1 7	.66	3	+1 7	0
83 Often talks about what he wishes to do when he grows up (vocational interest)	+1 4	.93	9	+1 3	0
84 Takes an active part in sports	+1 4	85	1	+1 2	0
85 Often walks aimlessly around the classroom	—1.1	.78	16	—1 5	0
86 Often writes aimlessly on the board or draws before class	— 9	73	16	—1 2	0
87 Often looks around the classroom in an apparently aimless manner	— 9	57	19	— 9	0
88 Often shows his work to a visitor of his own accord	+ 6	1 35	13	+ .8	10
VIII Scholarship and study habits					
89 Usually works well without seeking praise	+2 2	.79	0	+2 2	0
90 Usually pays close attention to instructions and explanations of teacher	+2 2	62	0	+2 0	0
91 Usually pays no attention to distractions while working	+2 0	.92	3	+2 4	0
92 Usually works eagerly on class assignment	+1.9	.59	4	+1 8	0
93 Often asks questions for information	+1 9	94	8	+2 0	0
94 Usually works very hard	+1 9	66	4	+2 0	10
95 Usually carefully takes down assignment	+1 8	69	4	+1 6	0
96 Usually does work neatly and carefully	+1 7	.66	5	+1.7	10
97 Usually gives up as soon as a difficulty arises	—1 6	91	8	—2 3	10
98 Usually does class assignments correctly	+1 4	93	2	+1 4	0
99 Usually works as well after twenty minutes of effort as after two minutes of effort	+1 4	1 04	11	+1 3	0
100 Usually answers questions correctly	+1 4	98	4	+1 8	0

Validity

As to whether or not the scale really measures personality, the original evaluation of items is itself a standard for judging. No real criterion is available, but it would seem that when the judg-

ments of a large number of experts have been pooled we have as valid a scale as is possible at present It is significant that of the 100 items of the scale, only 13 differences of .6 or more were found between the opinions of Groups A and B.

For the purpose of throwing light upon the validity of the scale, fourteen teachers in the Milne Junior High School in Albany, New York, were each asked to rate the following four students in her class. the most desirable personality, the second most desirable personality, the next to the most undesirable personality, the most undesirable personality The results of these ratings were as follows

Group	Median	Range
Most desirable personalities	+605	+925 to +255
Second most desirable personalities	+605	+885 to +175
Next to most undesirable personalities	+ 9	+535 to —345
Most undesirable personalities	— 85	+265 to —445

In the Milne Junior High School, seven supervisors, who are also home-room teachers, were asked to select the most desirable personality among their students and the most undesirable, and to rate them. The following results were obtained:

Supervisor	Most desirable	Most undesirable
1	+970	+209
2	+884	+ 75
3	+883	+ 21
4	+705	— 35
5	+604	— 97
6	+470	—215
7	+262	—323
Median	+705	— 35

These data indicate that the scale definitely differentiates desirable and undesirable personalities

Reliability

There are several factors which contribute to the reliability of this scale. The 100 items give a good sampling of behavior The rater is required to indicate the presence or absence of small units of behavior rather than to evaluate behavior. The wording of items

and directions was carefully tested by preliminary trials An objective method of scoring is provided The reliability coefficient of the scale, obtained by correlating the sums of the scores of the odd-numbered items with the sums of the scores of the even-numbered items for 100 papers taken at random, was .88 ± .015 This became 94 when the Spearman-Brown prophecy formula was applied

The agreement between two different raters of the same subject was tested by correlating the scores of any two ratings on each of 100 children for which two or more ratings were available The process was repeated for another sampling of 100 children. The correlations obtained were +.36 and +.33, respectively. The ratings were done by student teachers who had taught the children in one class for approximately eight weeks. It is probable that a higher reliability can be obtained when the raters are more experienced teachers and better acquainted with their pupils In this connection, it should be pointed out that, since personality is a matter of the individual's interaction with the environment, the most significant part of which is the personalities of other individuals, very close agreement between raters is not to be expected.

Norms

Norms were obtained by securing 801 pupil ratings by teachers in New York, Connecticut, Ohio, North Carolina, South Carolina, Virginia, Tennessee, Florida, Kentucky, and Texas. Types of schools represented are city, village, and rural, from those with one teacher only to those with very large staffs. Table 2 gives the medians and Q's by age and sex groups for the total scores. Table 3 gives the percentile norms for the total scores of the group of 801 pupils, since the differences between ages and sexes do not seem large enough to warrant the use of separate norms for each group Similar tables have been prepared for each of the eight situational groups By use of these tables, personality profiles may be drawn as shown in Figure 1

An examination of the medians shows some interesting age and sex differences Girls' scores are consistently higher than boys' scores Also, the scores decrease as the age level rises. Within the sex groups there are two exceptions to this general trend The 13-year-old boys' scores are higher than the 12-year-old boys' scores,

and the 14-year-old girls' scores are higher than the 13-year-old girls' scores.

Uses of the Scale

The scale may be used both for survey and diagnostic purposes. It will probably work most effectively where there is a guidance set-up or a home-room teacher. The persons to whom the information furnished by the scale is most important are probably the classroom and home-room teachers, the guidance counselor, the clinical worker, and the research worker. The ratings by different teachers

TABLE 2

Median Total Scores for Age and Sex Groups

Ages	Boys Number	Boys Median	Boys Q	Girls Number	Girls Median	Girls Q	Total Number	Total Median	Total Q
10	54	588	222	48	675	193	102	613	207
11	55	554	252	55	631	142	110	575	158
12	40	450	150	64	581	161	104	516	166
13	72	489	163	91	503	132	163	494	153
14	82	380	167	72	550	158	154	438	174
15	91	379	186	77	463	148	168	394	162
All ages	394	448	194	407	553	164	801	507	184

TABLE 3

Percentile Norms for Total Scores

Scores	Percentile norms	Scores	Percentile norms	Scores	Percentile norms
950—974	99	550—574	59	150—174	14
925—949	99	525—549	55	125—149	12
900—924	98	500—524	51	100—124	10
875—899	97	475—499	47	75— 99	9
850—874	96	450—474	44	50— 74	8
825—849	95	425—449	41	25— 49	6
800—824	93	400—424	37	0— 24	5
775—799	91	375—399	34	— 1— 25	4
750—774	88	350—374	32	— 26— 50	3
725—749	86	325—349	30	— 51— 75	2
700—724	82	300—324	27	— 76—100	1
675—699	80	275—299	25	—101—125	1
650—674	76	250—274	23	—126—150	0
625—649	73	225—249	21	—151—175	0
600—624	69	200—224	18	—176—200	0
575—599	64	175—199	16		

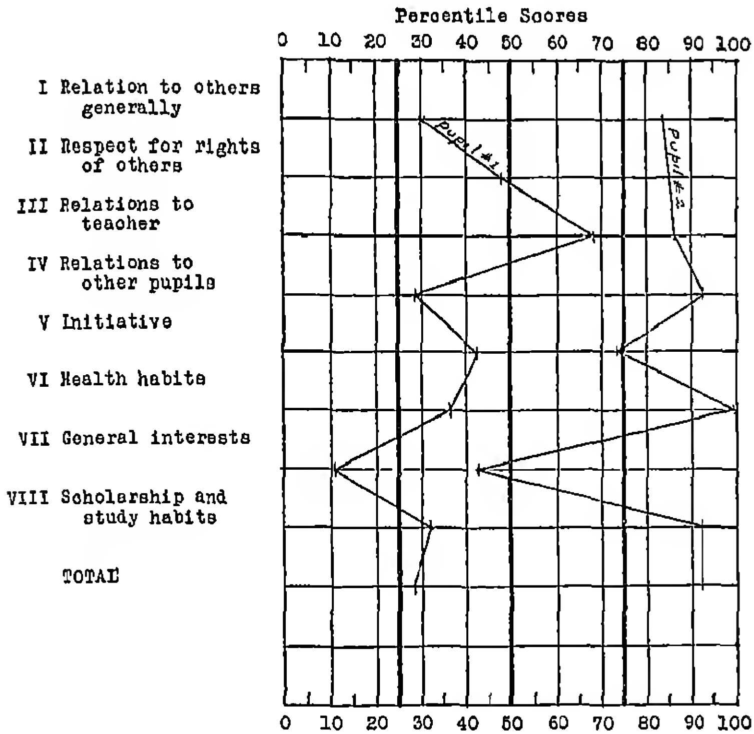

FIGURE 1
Personality Profiles

furnish the home-room teacher with valuable information concerning the habits of her individual pupils Clues are often discovered in this way as to problems of teacher-pupil relationships which will be helpful in the handling of child problems. Since different people vary in rating the same individual, it is desirable to secure several ratings for the same child and to use a composite score in order to obtain a more reliable total picture of the child's behavior. There is value in studying all ratings as indicating variations of behavior of the same individual in different situations. Variations of behavior in different classes may throw light on causes of success and failure Children may be rated at the end of each semester

and a record kept from year to year of their composite ratings in order that variations in progress may be noted. Profiles similar to those given in Figure 1 may be kept for each child.

Personality problem cases may be "spotted" by noting pupils whose total scores are below the norm. Further comparison of their scores in the different situational groups will help to locate their strong and weak points more specifically. The undesirable habits of any child may be located by noting the items with negative scores and the seriousness of each habit will be indicated by its value on the scoring sheet

Some research studies in which use is made of the scale are now in progress. One of these has as its purpose a study of behavior patterns characteristic of adolescent delinquents in order to obtain clues for the purpose of locating these cases in their early stages Another study is concerned with the changes in behavior patterns of children whose parents regularly attend parent-study groups as compared with those whose parents do not attend such groups Other studies in progress are for the purpose of comparing ratings made by parents with self-ratings made by the children of these parents, and of comparing teacher and pupil self-ratings on the same children. Another study is concerned with differences in reactions of children to the home and school situations.

Summary

Rating scales have been constructed for estimating and interpreting the personality development of adolescents in the home situation and in the school situation. These scales are an attempt to help meet the need for new educational techniques that has arisen with the new emphasis in education upon the development of character or personality Emphasis has been placed upon the use of the scales for diagnostic purposes.

The Personality Rating Scale for the Adolescent in the School consists of 100 items These items were obtained by observing the behavior of adolescents and retaining those habits for the scale about which experts could agree fairly closely, and which were considered by them to have some significance for personality development The items on the scales are in terms of specific behavior rather than general habits The reliability of the scale is .94,

obtained by correlating the odd and even scores of 100 papers. There is evidence of the validity of the scale as shown by the fact that it definitely discriminates between desirable and undesirable personalities in adolescent children.

There is a great need for more experimentation in this field. Development of character and personality is recognized as a fundamental aim in education, but theory cannot progress far without techniques which are objective and reliable. Much has been accomplished in this field, but there are still many difficulties in the way. These are being gradually overcome and it is probable that the near future will find theories of personality development more firmly supported by data gathered by the use of reliable techniques in this field.

References

1. DOWNEY, J. E. The will-temperament and its testing. New York: World Book Co., 1923. Pp. 339.
2. HARTSHORNE, H., & MAY, M. A. Studies in deceit. Book 1. General methods and results. Book 2. Statistical methods and results. New York: Macmillan, 1928. Pp. xxi+414, ix+306.
3. HARTSHORNE, H., MAY, M. A., & MALLER, J. B. Studies in service and self-control. New York: Macmillan, 1929. Pp. xiv+560.
4. HARTSHORNE, H., MAY, M. A., & SHUTTLEWORTH, F. K. Studies in the organization of character. New York: Macmillan, 1930. Pp. 503.
5. HAYES, M. The teacher and personality tests. *N. Y. State Educ.*, 1932, 19, 349-351.
6. KOOS, L. V., & KEFAUVER, G. N. Guidance in secondary schools. New York: Macmillan, 1932. Pp. 651.
7. SHERMAN, M. Theories and measurement of attitudes. *Child Develop.*, 1932, 3, 15-28.
8. STODGILL, R. M. Parental attitudes and mental hygiene standards. *Ment. Hygiene*, 1931, 15, 813-827.
9. VOELKER, P. F. The function of ideals and attitudes in social education. *Teach. Coll. Contrib. Educ.*, 1921, No. 112. Pp. 126.
10. WATSON, G. A critical note on two attitude studies. *Ment. Hygiene*, 1933, 17, 59-64.
11. WICKMAN, E. K. Children's behavior and teachers' attitudes. New York: Commonwealth Fund, Div. Publ., 1928. Pp. 247.

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UNE ÉCHELLE POUR L'ÉVALUATION DE LA PERSONNALITÉ ADOLESCENTE

(Résumé)

On a construit des échelles d'évaluation pour estimer et interpréter le développement de la personnalité des adolescents dans le milieu familial et dans le milieu scolaire On a construit ces échelles dans le but d'aider à former les nouvelles techniques nécessaires à cause de la nouvelle importance donné dans l'éducation au developpement du caractère ou personnalite On a appuyé surtout sur l'emploi des échelles pour la diagnose

"L'Échelle pour l'Évaluation de la Personnalité de l'Adolescent à l'École" se compose de 100 parties On a obtenu ces parties au moyen d'observer le comportement des adolescents et de retenir les habitudes pour l'échelle à l'égard desquelles les experts ont pu s'accorder et lesquelles, selon ceux-ci, ont quelque signifiance dans le developpement de la personnalite Les parties des échelles sont en termes du comportement spécifique, plutôt qu'en termes des habitudes générales La constance de l'échelle est de 0,94, obtenue par la corrélation des résultats pairs et impairs de 100 papiers La validité de l'échelle se montre dans le fait qu'elle fait une discrimination définie entre les personnalités désirables et non désirables chez les enfants adolescents

HAYES

EIN MASS FÜR DIE SCHATZUNG DER JUGENDLICHEN PERSÖNLICHKEIT

(Referat)

Man stellte Schatzungsformulare (scales) auf zur Wertung und Deutung der Personlichkeitsentwicklung bei Jugendlichen im Heim und Schulmilieu Diese Masse (scales) stellen einen Versuch dar, den Bedurfnissen der neuen erzieherischen Technik entgegenzukommen, die mit der neuen Betonung in der Erziehung der Charakterbildung oder Personlichkeit aufkam. Es wurde der Gebrauch von Massen (scales) fur diagnostische Zwecke betont.

Die "Personality Rating Scale for the Adolescent in the School" (Schatzungsformulare fur die Personlichkeit der Jugendlichen in der Schule) besteht aus 100 einzelnen Angaben Diese Angaben wurden dadurch erhalten, dass man das Verhalten Jugendlicher beobachtete und jene Gewohnheiten fur diese Formulare zuruckbehielt, uber die sich die Sachverstandigen ziemlich gut verstandigen konnten, und die von ihnen als bedeutungsvoll in der Personlichkeitsbildung betrachtet wurden Die Angaben der Formulare haben eher die Form spezischer Verhalten als allgemeiner Gewohnheiten Die Zuverlassigkeit (reliability) des Masses ist 0,94, ein Wert, der durch die Korrelation der geraden und ungeraden Punktzahlen von 100 Exemplaren gefunden wurde Die Gultigkeit des Formulars ist dadurch erwiessen, dass es bestimmt zwischen wunschenwerten und unerwunschten Personlichkeiten unter jugendlichen Kindern unterscheidet.

HAYES

SHORT ARTICLES AND NOTES

THE INTELLIGENCE AND EDUCATION OF CHILDREN HANDICAPPED BY CEREBRAL PALSY

Elizabeth Lord

For some years interest in educating the crippled child has been increasing, but only recently has the interest extended to children with cerebral palsy Now physicians, psychologists, and teachers are beginning to concern themselves with the educational problem that these children present The diagnosis of cerebral palsy implies a difficulty, of varying degrees of severity, in motor control This disability may be a negligible handicap or it may so involve the legs, arms, and even the speech mechanism that the child has practically no means of expression Everyone appreciates the difficulty of estimating mental capacity when a child cannot speak or use effectively his hands, but in the cases where there is only a mild disability, persons, trained and untrained, approach the problem with more confidence and often express an opinion that carries undue weight In regard to the same child one often finds conflicting opinions expressed by persons experienced in the management of the cerebral palsied; one person believes the child cannot be educated in the ordinary academic subjects, while another thinks the child has normal intelligence and sets no limits to his educational possibilities. Among the cerebral palsied there are a few individuals who, in spite of severe physical disability, have successfully completed high school and college and have even skipped a grade in the process, but there are many children wasting hours in a futile struggle toward unattainable goals As long as we have no objective data in the form of reliable test results, we are reduced to a trial-and-error method swayed by the weight of one person's opinion against another's Often a doctor after casual conversation with the child accepts the parents' point of view that the child is "bright" and the child and the teacher may be placed in an intolerable position If through diagnostic tests we can demonstrate the child's abilities and disabilities we may be able to plan an effective educational program that will eliminate a long struggle and inevitable disappointments

In a recent book, "Mental Deficiency as a Result of Birth Injury," by Edgar A Doll (1), the results of mental testing on a group of cerebral palsied are presented Of the tests given, the Stanford-Binet rating was considered the most satisfactory, "a fair approximation of the true intelligence level." Several of the cases reported by Dr Doll have Stanford ratings which classify them in the dull normal group, but, as Dr Doll points

out, "the interpretation of the results must be rendered in terms of clinical analysis rather than in terms of numerical interpretation," and he further suggests diagnostic teaching as an illuminating procedure

With this point of view in mind, it may be helpful to review a few cases that were studied and followed through their early years while the problem of an education program was acute and tense with emotion

Case 1 Diagnosis mild cerebral palsy, extra-pyramidal From the history we learn that the boy talked late and did not walk alone until seventh to eighth year At the first psychological examination when the child was ten years old, he walked with complete independence, talked with some hesitation but intelligibly and could use his hands fairly well, that is, writing was difficult, but many children with much less control manage successfully written work The nurse who had taken care of him from infancy considered him intelligent and the doctor in charge made no reservation as to his educability. The mental age (Stanford) = 8 2/12 years IQ–81

An analysis of the psychological examination presented the following assets and liabilities on which to plan a constructive program·

Assets

1 Many favorable personality traits Child was cooperative, obedient, equable when certain requests were denied, and listened to the reasons given for changes in plans showing adequate social adaptability in these situations for his age.

2 Good vocabulary (X-year Binet) used well in ordinary conversation.

3 Fair success in the field of audition According to the report, he appreciated stories for his age when read to him. His recall of a passage read approximated expectation for his age He had greater success on tests given orally than in any other type of test situation.

Liabilities

1 Extreme distractability. During the examination the child was more restless and distractable than most kindergarten children He did very poorly in all tests that require a special degree of concentration, i e, he repeated 6 digits (X-year Binet) but could not reverse 3 digits (VII-year Binet) He could count forward but not backward from 20 to 1 (VIII-year Binet). If his attention was constantly recalled (invalidating the test score) he would greatly increase scores in several tests

2 Poor visual memory Child could not go beyond the first line in the cube imitation test, could not reconstruct Healy A after he had seen it completed several times, or draw a very simple design from memory In spite of individual instruction for about two years, he could not read a simple passage from a primer and after he had been told such words as "bird" and "house" he did not recognize them a few lines later on. He omitted a letter in printing his name but did not detect the omission, although the next day he printed his name correctly

3 Defect in dealing with abstractions. He could count 13 pennies but failed simple problems if the sum of the numbers was above 5 He could name the coins but had no idea of their relative values, 6 was more than 9, etc

4 Defect in motor control Although he could draw a straight line he could not reproduce the diamond and had very poor memory of motor patterns (related to visual memory) The motor handicap involving speech placed him at a marked disadvantage in a group of children

Summary Impression that the child did not have sufficient general intelligence and auditory memory to compensate for the poor concentration, visual memory defect, and motor handicap Consequently we should expect him to have very limited progress in academic subjects even under individual instruction. The child's happiness and later adjustment may depend in large measure on developing an interest that is largely independent of academic training

Two years later (making four years of special instruction), although the child had been taught under the direction of a highly experienced teacher, we found the following situation The boy was not timid with a stranger but he lacked the spontaneity previously shown He hesitated before opening his book and he looked definitely perturbed when asked to write his name He read glibly from his primer but he could not read an unfamiliar passage in a second-grade reader, confusing simple words and substituting words without meaning He read slightly better when a card was held below the line (perhaps there is a muscle imbalance that caused difficulty in maintaining steady focus across the page) His writing from copy was more legible, but he wrote "se" for see repeatedly, and became confused in writing his name. He was working on sums within 20 but his answers were unreliable and he was still making such mistakes as reversing his numbers, 91 for 19

Case 2 Boy Diagnosis cerebral palsy Spastic When the child was first examined at 2 1/2 years, he was talking in full sentences He could pile 3-4 one-inch cubes (right hand preferred) At the first examination he could creep and pull himself to a sitting position but he has never been able to take a step alone In the repeated examinations he has always had a good vocabulary for his age and answered comprehension questions approximately at age In the last examinations his Stanford ratings have been respectively 83 and 82 at 6 4/12 and 7 3/12 years

For about two months, on two different occasions, while the child was in the hospital for intensive muscle training, diagnostic teaching was attempted In all situations, including even the meal hour, he showed a marked lack of concentration To the casual visitor who might hear him use correctly such words as "encephalogram," "special diet," "on precautions," it would hardly seem possible that he could not be taught to count reliably above five and that he had practically no number concept Although he could draw a straight line, his sense of direction was so impaired that he could not reproduce a square, and having traced his three-letter name many times daily he could not reproduce it below the model. It was our impression that, in spite of the facility in language and the relatively high Stanford rating, the child was not educable in the ordinary school subjects

During the summer when he was seven an uncle tried unsuccessfully to teach him In the following spring the superintendent of school wrote that he had been interviewed by the parents. As the first-grade teacher was related to the family and knew the case thoroughly he would take the boy for a trial period in the school He was in school about two months, before summer vacation. His teacher reported that he gave no trouble in the classroom but that he made very little advance in school work. "This might be due in part to the fact that he entered during the later part of the year and existing classes were much in advance of him. He has entered school again this fall and is attempting to attend during both sessions He has a different teacher than he had last year She seems to think that he is capable of making some progress"

Another child who has even greater fluency in language gained at 7 10/12 years a mental age on the Stanford-Binet of 6 10/12, with an IQ of 87. His disabilities are essentially the same as reported for Case 2 The child was placed for a few weeks in a hospital school for special study which did not include a psychological examination. At the end of the period the parents were told without reservation that the child's mentality was in no way impaired. After a year of special individual teaching he was again re-examined. He could write his name but, when asked to write other words, his eyes filled with tears as he explained, "You see it's this way, they have to write it first and then I copy it and copy it and copy it."

As the cases of this type multiply and the results of the diagnostic teaching are confirmed by later studies, objective data can be accumulated, this will give a basis for prediction which we do not have at the present time Persons who are planning the educational program of these children should spend some time in teaching or should follow closely the work of an experienced teacher working under favorable conditions. In the type of case described it is apparently the child's power of verbalization which is largely responsible for the relatively high rating on the Stanford and the false impression of mental capacity given to parents, friends of the family, doctors, and even at times to the teacher As long as everyone insists that the child's mentality is not impaired an effort will be made to force the child in school work. The teacher will patiently spend an undue proportion of time on a child who is not educable along the lines laid down for the class and the child copies and copies and copies with a growing sense of inferiority.

REFERENCE

1. DOLL, E A, PHELPS, W M, & MELCHER, R. T. Mental deficiency due to birth injuries. New York Macmillan, 1932. Pp xvi+289

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THE FINGER MAZE AS A SUPPLEMENTARY TEST OF INTELLIGENCE FOR BLIND CHILDREN[1]

RALPH V MERRY AND FRIEDA KIEFER MERRY

During the past twenty years considerable attention has been given to the development of intelligence tests for blind children With the exception of a few tests of school achievement, however, practically all effort has been centered upon the adaptation of the Binet-Simon Scale and its revisions Sporadic attempts have been made to adapt some of the well-known performance tests, but the results have not been very satisfactory. In changing visual tests to tactual tests the experimenter frequently assumes that the same abilities are being measured, whereas this may not be the case. The finger maze, however, seems particularly well suited to measure the learning ability of blind individuals, since no special adaptation is necessary to compensate for lack of sight This has been demonstrated in the experiments made by Koch and Ufkess (4), Knotts and Miles (3), and by Duncan (1) The principal aim of these investigations was to compare the learning ability of blind with seeing groups, but it was shown, also, that mental age correlated significantly with success in maze learning It seemed to the writers, therefore, that tests of a maze-learning type should prove to be a valuable supplement to existing measures of intelligence for the blind, and in order to test this assumption they carried out the preliminary experiment described in this paper.

THE EXPERIMENT

Subjects The experiment was undertaken during the winter and spring of 1932 upon 30 children, 8 to 16 years of age, enrolled in one of the large eastern schools for the blind Both sexes were represented, but there were 19 boys and only 11 girls. Their mental ages ranged from 7 years 4 months to 18 years, with a median of 13 years, 5 months, their IQ's, from 81 to 146, with a median of 111 Of these 30 children 83 per cent lost their sight before the age of five, 33 per cent being blind from birth, and an additional 23 per cent being blinded within the first year of life

Apparatus The high-relief maze used was the same as that employed by Knotts and Miles It is a multiple-T pattern wherein each true path is balanced by a corresponding cul-de-sac and is constructed of wire staples driven into a board about 18 inches square The paths are numbered to facilitate the recording of errors, there being 10 culs-de-sac and 10 true paths The high-relief maze was chosen for the present experiment rather than the stylus maze, as the former permits direct finger contact, and has been shown to be equally difficult for both blind and seeing subjects

[1]The writers wish to express their sincere thanks to Dr Walter R Miles for loaning the apparatus used in this study, and also for his cooperation and interest.

Procedure The child was seated comfortably at a table of convenient height with the maze directly in front of him Blindfolding was not considered necessary, as no subject had sufficient vision to aid him in learning the pattern The child was then instructed as follows:

"I want to see how well you can solve this puzzle (directing the child's attention to the sample pattern on the board) Here is a path which looks something like our underground tunnel,[2] and you are to find your way out without getting lost. Let's try it You start here where there is one tack (E places child's finger on correct spot). Follow the path until you come to two tacks (E shows child) and then you know you are out" If the child went down the wrong path the examiner exclaimed, "You're lost! Now, which way should you go?" After the child had grasped the idea, the examiner said, "Over here is a puzzle just like the one you've been doing, but it is much longer and harder" Examiner then puts child's finger on the starting-place and says. "Let's see how quickly you can find your way through this tunnel without getting lost If you go down the wrong path, bring your finger back on the same path and go in the other direction You may get lost a good many times at first, but you'll soon learn your way. Go ahead"

Many of the children had a tendency to travel backwards after going into a cul-de-sac, and the examiner had to tell them to go forwards With few exceptions the children finished in one or two sittings One child, however, required a sitting every day over a period of a week before she achieved the criterion of learning, which was three successive correct tracings of the maze.

Individual records were made of the total number of trials, total number of errors, total time, average time per trial, and method used in learning the maze. The frequency of the errors made in each cul-de-sac also was noted in order to determine its relative difficulty

Results

The results given in Table 1 were obtained from the 30 children tested.

TABLE 1

	CA (months)	MA (months)	IQ	Trials	Errors	Time (sec)	Av time each trial (sec)
Mdn.	141	161	111	37	86 5	1186	30
Q dev.	15 5	26	14 5	20 5	11 75	598	5 75

Our results compare favorably with those of Knotts and Miles (3, p. 31), considering the fact that the children in this investigation were younger and less homogeneous in both chronological and mental age.

[2]At the school where this experiment was conducted all buildings are connected by underground passages which the children use in inclement weather.

Correlations (using the Spearman rank-difference method) between chronological age, mental age, and the various maze-learning scores were computed, and are given in Table 2

TABLE 2

	MA	Trials	Errors	Time	Av time
CA	58± 07	46± 09	44±.10	57± 07	20±.11
MA		54± 09	54± 09	61± 07	21±.11
Trials			93± 02	88±.02	—18± 11
Errors				89±.02	—09± 12
Time					22±.11

The correlations between errors and trials, errors and time, and between trials and time all are high and show small probable errors These three measures of maze-learning ability are more reliable than the average time per trial, which shows both low negative and positive values with large probable errors Mental age correlates more closely with maze-learning ability than does chronological age Total time appears to be more closely related to mental and chronological age than are trials or errors Our findings in general are in substantial agreement with those of Knotts and Miles (3) when allowance is made for the greater variability of the children in the present study

An analysis of the errors made by these 30 blind children in learning the high-relief maze (computed according to the frequency of error in each cul-de-sac) shows that the culs-de-sac 17, 7, and 11 are particularly difficult, while 3, 1, and 19 are relatively easy These findings agree with the results of Knotts and Miles (3, p 39) with one exception They found cul-de-sac 9 among the less difficult, whereas number 1 was easier than number 9 for our blind children.

It was sometimes difficult to ascertain the method employed by each child in learning the high-relief maze Their answers, however, are tabulated thus

	Verbal method	Motor	Verbal-motor
Percentage of children	26 66	66 66	6 66

It will be seen, therefore, that the majority of our children incline to the motor method of learning, although Knotts and Miles (3, p 43) in their study of older blind children found the verbal method to be superior

Our results do not permit comparison with previous studies in regard to the influence which extent and duration of blindness have upon maze learning, since 83 per cent of the children in our study lost their sight before the age of five years[8] The relation between the total number of trials

[8]In classifying our subjects according to age of blinding we used the method employed by Hayes (2)

required to learn the high-relief maze and age of blinding was .06 ± .12; between total number of errors and age of blinding, .09 ± .12, and .01 ± .12 between total time and age of blinding. Since these correlations are very low and their probable errors are high, it appears that age of blinding is not of great importance so far as this experiment is concerned.

Summary and Conclusions

1. From our results we believe that the finger maze should be a valuable supplement to existing intelligence tests for blind children, particularly between the ages of 10 and 14.

2. The median maze performance of our 30 cases compares favorably with that of a group of older blind children tested by Knotts and Miles. No norms of accomplishment can be computed, however, until a large and representative sampling of blind children at various age levels has been examined.

3. The high intercorrelations between trials, errors, and time indicate that these should prove to be satisfactory measures of maze-learning ability.

4. Mental age (as computed by existing intelligence scales) correlates more closely with maze learning than does chronological age.

5. With one exception, the easiest and most difficult alleys in the maze were the same for our subjects as for those of Knotts and Miles.

6. The motor method of learning characterized the children in this investigation, whereas Knotts and Miles, whose subjects were older, found the verbal method to be used more frequently.

7. For the children in this study the age at which vision is lost seems to have no appreciable effect upon maze performance.

References

1. Duncan, B. K. A comparative study of finger-maze learning by blind and sighted subjects. *J. Genet. Psychol.*, 1934, 44, 69-95.
2. Hayes, S. P. Preliminary study of the influence upon school success of the age at which vision is lost. *Proc. Amer. Asso. Instruct. Blind*, 1921, No. 2. Pp. 60.
3. Knotts, J. R., & Miles, W. R. The maze-learning ability of blind compared with sighted children. *J. Genet. Psychol.*, 1929, 36, 21-50.
4. Koch, H. L., & Ufkess, J. A comparative study of stylus maze learning by blind and seeing subjects. *J. Exper. Psychol.*, 1926, 9, 118-132.

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A QUARTER CENTURY OF DELAYED RECALL[1]

L. B Hill

Twenty-five years ago the writer and A. E Rejall, students in Teachers College, Columbia University, learned to typewrite under experimental conditions The experiment consisted of learning to use the typewriter by copying daily a 100-word paragraph, and by copying, at the same sitting, a page of new material containing 300 words The original data were analyzed by Dr E L Thorndike and published in the *Pedagogical Seminary* for December, 1913, under the title "Practice in the Case of Typewriting" (1).

During the four years following the experiment, 1908-1912, the writer had access to a typewriter in the office of a small high school and occasionally wrote a few letters For the next five years he did not use the typewriter, since he had secretarial help In the summer of 1916 he copied a manuscript of about seventy-five pages Form 1916 to the present time—that is, to the beginning of the recall experiment herein described—he has had no occasion to use a typewriter, since all his writing has been done by a stenographer He has therefore had no practice whatever during twenty-one of the twenty-five years that have elapsed from the time of the original experiment to the beginning of the present one Such practice as he had in the other four years tended to reduce speed for the sake of accuracy. It may be claimed that the intervening practice promoted accuracy, however, there is little or no evidence in support of this claim in the recall experiment

In December and January, 1932-1933, the writer attempted to study the conditions of recall of the skill attained in the original experiment a quarter of a century ago. Beginning on December 17, he copied the same 100-word paragraph and a 300-word page of new material each day until he had attained a skill in the use of the typewriter equal to and beyond that which he had attained at the end of the original experiment The data are given in Table 1 parallel with sections of the data of the original experiment[2] Figures 1 and 2 show the complete data in both experiments in terms of words written per minute The factor relating to errors was eliminated by penalizing the experimenter two words for each error

An analysis of the data shows that at the beginning of the recall experiment on December 17, 1932, the experimenter wrote the 100-word paragraph in 4 minutes and 45 seconds with six errors, and the new 300-word page in 17 minutes and 50 seconds with 41 errors The average of the first four practices reveals that he was writing the 100-word paragraph at the rate of 20.4 words per minute (deducting two words for each error) and

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[1]The writer and experimenter is indebted to Dr Thorndike, author of the article on the original experiment, for some of the methods of treating the data of the recall experiment.

[2]For complete data on the original experiment see (1)

TABLE 1

A QUARTER CENTURY OF DELAYED RECALL

	Excerpts from original experiment: Same 100-word paragraph			300-word page of new material		
	Minutes	Seconds	Errors per 100 words	Minutes	Seconds	Errors per 300 words
1907 Nov 1	10	00	13	42	00	57
2	10	00	12	37	00	48
4	9	45	13	30	30	45
5	9	00	2	31	00	45
21	5	38	6	22	45	25
22	6	00	4	20	52	21
23	5	19	9	21	50	11
25	5	23	4	21	00	10
26	5	35	5	20	14	12
27	5	15	3	17	37	12
28	5	15	1	18	29	16
30	5	15	3	20	20	11
Dec. 2	6	5	1	22	32	13
3	5	15	1	22	46	8
4	5	40	6	21	00	16
5	5	55	3	22	20	3
6	5	16	2	21	51	7
7	4	43	0	19	25	9

	Complete recall data after 25 years: Same 100-word paragraph			300-word page of new material		
	Minutes	Seconds	Errors per 100 words	Minutes	Seconds	Errors per 300 words
1932 Dec 17	4	45	6	17	50	41
18	4	20	5	23	15	19
19	5	00	8	16	20	20
20	4	05	2	15	05	15
21	4	50	7	15	50	25
22	3	50	8	20	35	15
23	3	55	8	15	15	15
24	3	25	4	13	40	10
25	3	20	4	14	15	29
26	3	30	6	14	05	6
27	3	10	1	14	45	17
28	3	05	8	14	45	15
29	3	30	13	12	55	15
30	3	30	6	12	20	17
31	3	00	2	11	50	20
1933 Jan 1	3	15	5	13	30	18
2	3	25	4	12	00	13
3	3	00	4	11	55	5
4	3	10	9	11	18	12
5	2	45	12	11	20	18

TABLE 1

	Excerpts from original experiment					
	Same 100-word paragraph			300-word page of new material		
	Minutes	Seconds	Errors per 100 words	Minutes	Seconds	Errors per 300 words
9	5	00	2	18	50	4
10	4	30	2	19	40	10
1908						
Mar 26	2	53	6	12	20	18
27	2	48	9	13	30	9
28	2	59	6	11	45	6
30	2	48	3	12	50	14

(*continued*)

	Complete recall data after 25 years					
	Same 100-word paragraph			300-word page of new material		
	Minutes	Seconds	Errors per 100 words	Minutes	Seconds	Errors per 300 words
6	2	40	7	12	10	19
7	3	05	3	11	48	9
8	2	47	5	13	00	11
9	3	00	6	13	00	10
10	2	45	2	11	15	7
11	2	55	8	12	10	14
12	2	45	3	12	30	9
13	2	50	4	12	30	7
14	2	32	6	11	40	10
15	2	35	3	12	30	13
16	2	48	2	12	30	6
17	2	45	2	12	35	5
18	2	30	1	11	45	11

TABLE 2

NUMBER OF WORDS WRITTEN PER MINUTE—DEDUCTING TWO WORDS FOR EACH ERROR—SAME 100-WORD PARAGRAPH

Original experiment								Recall experiment	
1	7.4	33	17.0	63	29.4	93	30.7	1	19.8
2	7.6	34	20.5	64	28.3	94	26.8	2	21.4
3	7.8	35	22.0	65	29.5	95	30.1	3	16.8
4	10.7	36	19.6	66	24.5	96	30.9	4	23.7
5	10.6	37	20.9	67	28.4	97	31.3	5	19.1
6	9.6	38	22.7	68	29.1	98	29.8	6	24.0
7	11.5	39	20.1	69	29.0	99	29.8	7	23.6
8	11.3	40	22.1	70	28.3	100	30.9	8	28.3
9	14.8	41	23.2	71	28.1	101	27.0	9	26.2
10	13.4	42	23.0	72	29.0	102	25.6	10	26.7
11	14.9	43	23.0	73	28.5	103	33.7	11	31.6
12	13.7	44	23.0	74	29.3	104	27.9	12	27.5
13	15.3	45	22.4	75	28.2	105	28.2	13	22.4
14	16.5	46	22.5	76	33.3	106	30.1	14	26.7
15	15.3	47	22.5	77	27.0	107	30.5	15	32.0
16	15.6	48	23.5	78	28.4	108	36.3	16	28.6
17	16.3	49	23.5	79	29.0	109	36.1	17	25.8
18	15.3	50	23.5	80	27.7	110	34.7	18	28.0
19	15.7	51	27.6	81	29.6	111	35.5	19	26.4
20	17.5	52	25.8	82	29.1	112	30.0	20	31.0
21	16.8	53	24.3	83	26.0	113	29.8	21	35.8
22	18.2	54	26.8	84	29.9	114	37.7	22	30.8
23	19.0	55	28.0	85	28.2	115	30.0	23	36.4
24	18.2	56	22.4	86	30.9	116	31.0	24	29.3
25	16.2	57	27.4	87	29.0	117	30.0	25	39.1
26	19.0	58	24.5	88	29.1	118	35.2	26	32.9
27	16.3	59	28.2	89	28.7	119	30.9	27	38.4
28	16.9	60	25.9	90	28.3	120	36.0	28	33.6
29	18.6	61	24.2	91	29.1	121	37.0	29	37.9
30	22.5	62	28.6	92	28.5	122	36.8	30	40.0
31	19.2					123	34.7	31	38.7
32	22.3					124	33.6	32	39.2
						125	33.9	33	42.6
						126	37.9		

the 300-word page at the rate of 14.4 words per minute. Since these averages may be taken to represent the ability of the experimenter to typewrite the respective exercises at the beginning of the recall, it may be seen by referring to the data on the original experiment in Table 1 that they correspond most nearly to ability which had been attained 25 days after the beginning of the original experiment. Therefore, the experimenter showed at the beginning of the recall approximately 20% of the skill he had formerly attained at the end of the 126 days' practice in the original experiment.

Initial performance shows only one phase of recall. It was necessary to find the amount of practice needed to re-establish the skill attained at the

Original experiment								Recall experiment	
1	4 4	33	15 2	63	19 1	93	19 7		
2	5.4	34	15 7	64	18 3	94	19 6	1.	12 4
3	6 5	35	14 0	65	18 2	95	17 7	2	11 3
4	6 5	36	13 6	66	20 0	96	18 3	3	16 0
5	8 2	37	16 8	67	17 3	97.	20 7	4	17.9
6	9 3	38	15 1	68	19 7	98	21.9	5	16 1
7	9.8	39	15 6	69	18 1	99	20 9	6	13 2
8	9 6	40	16 5	70.	19 4	100	18.6	7	17 8
9	10 0	41	15 6	71	19 1	101	19 1	8.	20 9
10.	10 4	42	16 2	72	18 1	102	19 6	9	17 1
11	10 5	43	15.7	73	18 0	103.	20 5	10	20 5
12	10 5	44	17 1	74.	20 2	104	19 2	11.	18 4
13	13 3	45	16 6	75.	17.3	105	21.3	12	18 7
14	12 4	46	15 1	76	18 0	106	21 3	13	21.5
15	9 4	47	16.4	77	17 8	107.	22.5	14	21 8
16	10 4	48	18 0	78.	17 8	108	20 2	15	22 6
17	11 1	49	15 7	79.	19 2	109	22 4	16	19 8
18	12 5	50	16 2	80	19 1	110	21 2	17.	22 8
19	12 9	51	16 6	81	20 3	111	21 0	18	25 0
20.	13 3	52	16 9	82	19 7	112	20 4	19	24 6
21	13 7	53.	17 1	83	21.3	113	22 1	20	23 5
22.	16.1	54	17.3	84	20 4	114.	22 0	21	21 6
23	14 7	55	16.3	85	18.9	115	22 5	22	24 5
24	13 7	56	16 7	86	20 8	116	22 2	23	21.3
25.	12 2	57.	17 5	87	19.5	117.	22 5	24	21 6
26	12 6	58	18 3	88.	20.4	118.	22 6	25	25 6
27	12 7	59	17 5	89	18 9	119	21.7	26	22.4
28.	16 9	60	18 5	90	19 7	120	23 0	27	22 9
29	13 2	61	18 8	91	21 0	121.	20.7	28	23 3
30	14 6	62.	18 9	92.	22 0	122	21 2	29	24 5
31	15 7					123	22 1	30	22 2
32	14 5					124	21 2	31	22 1
						125	25 1	32	22 2
						126	21 8	33	24 2

end of the original experiment. The averages of the last four practices in the original experiment show that the experimenter was writing the 100-word paragraph at the rate of 35 words per minute (again deducting two words for each error), and the 300-word page at the rate of 22.5 words per minute. The four practices of the recall giving the same respective averages are found under January 8, 9, 10, and 11. Therefore, a total of 26 days was necessary to re-establish the former skill. Or, counting in hours of time in the original experiment, 8.6 hours were spent on the 100-word paragraph and 36 hours on the 300-word page, whereas in the recall experiment 25 years later, 1.5 hours were spent on the 100-word paragraph

TABLE 3

NUMBER OF WORDS WRITTEN PER MINUTE—DEDUCTING TWO WORDS FOR EACH ERROR—300-WORD PAGE OF NEW MATERIAL

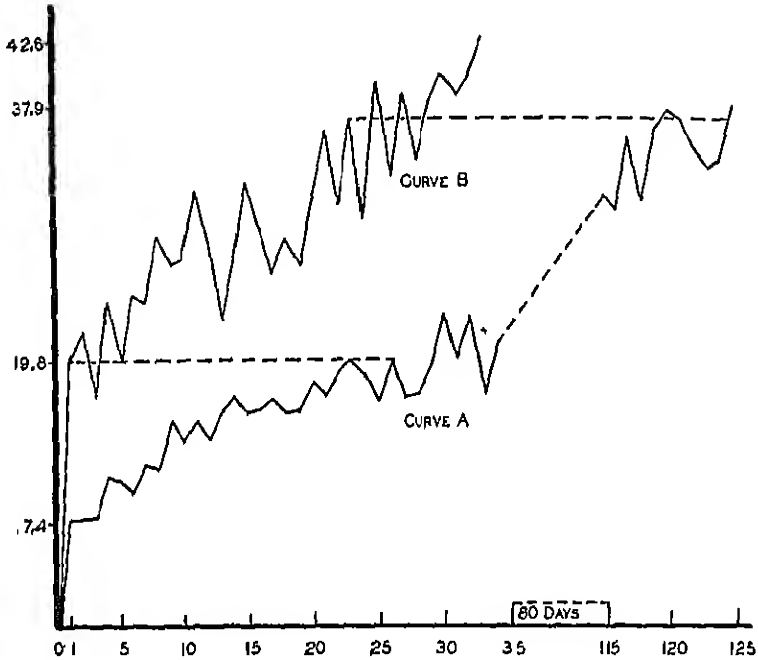

FIGURE 1

CURVES SHOWING IMPROVEMENT IN ORIGINAL AND RELEARNING EXPERIMENTS IN LEARNING TO TYPEWRITE (SAME MATERIAL)

Curve A shows the improvement in typewriting the 100-word paragraph in the original experiment

Curve B shows the recall in typewriting the same 100-word paragraph

The base line represents the number of days of practice. The vertical line represents the number of words written per minute

and 5 3 hours on the 300-word page One-fifth to one-sixth of the time was necessary to re-establish the former skill

Again the amount of practice required for recall may be seen if we estimate the number of strokes (or bodily reactions to stimuli) in the two experiments Approximately 511 strokes are necessary in writing the 100-word paragraph Since in the original experiment the paragraph was written 126 times, on as many days, 58,254 strokes were necessary to attain the final skill To attain the same skill through recall the paragraph was written 26 days during which time the experimenter made 10,220 strokes. On the 300-word page of new material he made 187,872 strokes during the original experiment. In order to secure the same skill through recall he made

32,860 strokes. Approximately one-sixth of the number of strokes were required *in relearning each exercise as in the original practice*

After completing the recall experiment the practice was continued for seven consecutive days, from January 12 to January 18. Considerable improvement may be noted in decreasing time and eliminating errors in the *100-word paragraph, and a slight elimination of errors in the 300-word new page* While the rate of learning is lower because the experimenter is doubtless approaching his physiological limit, he does not feel that he has reached his maximum skill in learning to typewrite

The learning curves for the original experiment and for recall present interesting contrasts The difference in length and the rapid rise of the latter in contrast to the former are the most outstanding Fluctuations from *day to day are found in all learning curves They are more* pronounced in this experiment than in the original experiment In fact, the fluctuations from day to day in recall of the 100-word paragraph are from two to three times as great as in the original learning This fact may be due to the *tendency of all habits (bonds) to function rapidly in recall when properly* directed and to function more slowly—even to be antagonistic to each other

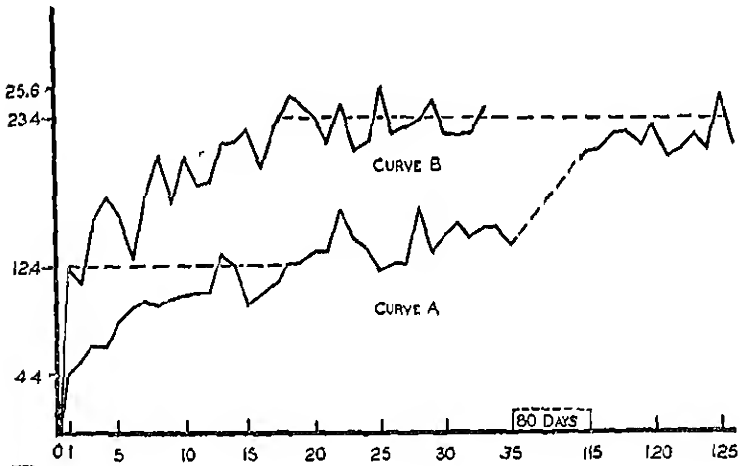

FIGURE 2

CURVES SHOWING IMPROVEMENT IN ORIGINAL AND RELEARNING EXPERIMENTS IN LEARNING TO TYPEWRITE (NEW MATERIAL)

Curve A shows the improvement in typewriting the 300-word page in the original experiment

Curve B shows the improvement in typewriting the 300-word page in the recall *experiment*

The base line represents the number of days of practice The vertical line represents the number of words written per minute

when misdirected The absence of the plateau is as evident in the recall curves, even when carried seven days beyond the practice necessary, as it was in the original.

Other factors revealed by an examination of the introspective notes are similar in both learning curves At the beginning of the original experiment there was a strong personal interest in learning to typewrite, there was the desire to discover certain facts about the way the experimenter himself learned, there was the desire to find a satisfactory project for class work in educational psychology, and the stimulus to prove himself a satisfactory graduate student At the beginning of the recall experiment there was a keen desire to discover facts about his (the experimenter's) ability to relearn, to do something that possibly no one else had done, to use the data for publication, to determine how much longer it would take him to relearn after twenty-five years than it took Mr Rejall to relearn after four and one-half years

Elation over relatively good scores, feelings of discouragement at poor ones, determination (even to the extent of gritting one's teeth) to succeed, physical condition, ventilation of the room, occasional interruptions by someone's coming into the room or slamming a door or banging the piano, were noted; yet these were doubtless minor factors in determining success in comparison with those mentioned in the preceding paragraph.

It is very difficult to discover the most potent factors in bringing about both speed and accuracy in "stroking" the keys of a typewriter In both the original learning and in the recall a favorable attitude on the part of the learner, generated by his belief in the specific value of the thing he was doing, confidence in his ability to do something a little unique, and faithful practice directed by his best thinking were necessary. After the above conditions have been met, the skill manifested through physical activity seems just "to happen." A strong will and determination seem to keep one practicing, but no amount of sheer willing without practice will secure an automatic reaction to a word when each element of the word has been reacted to separately.

REFERENCE

1 HILL, L. B, REJALL, A E, & THORNDIKE, E. L Practice in the case of typewriting *Ped. Sem*, 1913, 20, 516-529.

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SEX OF EXPERIMENTER AND INTELLIGENCE AS FACTORS IN MAZE LEARNING A FURTHER COMPARISON OF MAZE *AND SEX DIFFERENCES*

T C. Scott and E Underwood

Scott and Nelson (6), in comparing identical patterns of a high-relief finger maze and an improved form of stylus maze, found the differences in difficulty of the two mazes to be negligible. There was also a contradiction in these differences, since they existed in favor of the high-relief maze in terms of trials and errors and in favor of the stylus maze in terms of time They did find, however, a sex difference in favor of the boys in terms of all three criteria, which ranged in significance from 98 chances in 100 to practical certainty In attempting to account for this superiority of the boys in maze-running ability, the sex of the experimenters was mentioned as one possible factor It was stated that girls might be less at ease than boys in the presence of men

The main object of the present investigation was to test the effect of the sex of the experimenter, a second object was to make a further test for sex and for maze differences; and a third was to determine how important a factor intelligence was in such maze and sex comparisons Underwood and three other women students acted as experimenters for these 103 subjects

Apparatus and Experimental Procedure

The two mazes used in the former experiment (6) were used here The blindfold technique was the same and the experimental procedure, as a whole, was about the same, the only difference being that, since there were four experimenters, it was thought best to have more written and fewer oral instructions. In spite of this precaution, the authors are quite sure that a few of the subjects were not properly "broken in," and there is some doubt in regard to some others Some of the difficulties on the part of the subjects, however, appear to have been beyond the control of the experimenters, such as the intrusion of workmen during one experiment, the receiving of disturbing news from home by one student, and the lack of a proper understanding of the instructions in a few cases It might be pointed out, however, that most of the victims of these circumstances were boys How many other subjects may have been disturbed emotionally just prior to or during the experiment, the authors have no way of knowing They do know that four boys and only one girl gave reasons or excuses for their poor maze records And the question naturally arises whether these subjects would have been equally disturbed and would have offered these excuses had the experimenters been men

Altogether, the records of ten subjects have been eliminated from part of the calculations, those of five boys and five girls. The authors feel sure that the records of three of these boys should not be included, since there

was a visible emotional upset, and are reasonably sure that the records of the other two should not be included. They are also reasonably sure of three of the girls, but are much less sure of the other two These were the next two poorest records of girls and were eliminated mainly to make the number equal to the number of boys eliminated Calculations are given for 103, for 100, and for 93 subjects.

RESULTS

The two mazes are compared in Tables 1, 2, and 3. Table 2 is the one which should possibly be given most consideration, since there were more reasons for eliminating three boys than for eliminating any of the other seven subjects A similar comparison is found in Table 2 in the former experiment If these two tables are compared, it will be noticed that the results of the present experiment are uniformly lower, that is, better, than those of the former experiment, this being most evident in time This is possibly due to the fact that the written instructions were fuller in this experiment than in the former. The authors can suggest only two other possible reasons for these better scores, and they can be eliminated. First, there might be a difference in the level of the intelligence of the two groups of students, but that this is not true is shown later in the paper (see Table 10) Secondly, most of these students have come from Scott's classes and it might be thought that a student might not do so well for an experimenter who was also his instructor It has been found, however, that those subjects who learned mazes for Scott and those who learned mazes for Nelson were of about the same level of intelligence, and have practically the same averages on maze scores.

TABLE 1

COMPARISON OF MAZES

	Stylus maze N=49		Finger maze N=54			Diff
	Mean	σ	Mean	σ	σ_{diff}	σ_{diff}
Trials	17 51	9 65	18 15	12 97	2 24	29
Errors	40 20	22 87	39 59	28 25	5 05	12
Time (secs)	517 65	295 18	739 89	579 05	89 39	2 49

TABLE 2

	N=49		N=51			Diff
	Mean	σ	Mean	σ	σ_{diff}	σ_{diff}
Trials	17 51	9 65	16 33	10 78	2 04	58
Errors	40 20	22 87	35 24	21 73	4.46	1 11
Time (secs)	517.65	295 18	660 18	437 00	74 32	1 92

TABLE 3

	N=46		N=47			Diff
	Mean	σ	Mean	σ	σ_{diff}	σ_{diff}
Trials	15 70	6 27	14 17	7 64	1 45	1 06
Errors	35 59	13 78	30 53	15 04	2 99	1.69
Time (secs)	505 37	294 29	571 23	312 30	62 91	1 05

A point to note, however, in the comparison of these two tables is the fact that the trends found in the former experiment are also found here That is, the stylus maze is more difficult in trials and errors and less difficult in time The significance-of-difference column also substantiates the findings *in the other* experiment, the significance being less for trials than for errors or time. This substantiation points toward an actual difference, but it does not indicate that a completely reliable statistical difference exists between the two mazes

TABLE 4
COMPARISON OF SEXES

	51 boys		52 girls			Diff.
	Mean	σ	Mean	σ	σ_{diff}	σ_{diff}
Trials	18 06	11 89	17 63	11 13	2 27	19
Errors	40 10	26 93	39 67	24 70	5 09	08
Time (secs)	616 45	530 63	651 54	421 83	94 57	37

TABLE 5

	48 boys		52 girls			Diff
	Mean	σ	Mean	σ	σ_{diff}	σ_{diff}
Trials	16 13	9 16	17 63	11 13	2 03	.74
Errors	35 50	19 45	39 67	24 70	4 43	94
Time (secs)	524,04	318 13	651 54	421 83	74 37	1,71

TABLE 6

	46 boys		47 girls			Diff
	Mean	σ	Mean	σ	σ_{diff}	σ_{diff}
Trials	15 15	7 75	14 70	6 25	1 46	31
Errors	33 11	16 04	32 96	13 14	3 04	05
Time (secs)	512 20	308 37	564 55	299 99	63 11	83

The two sexes are compared in Tables 4, 5, and 6 A similar comparison is found in Tables 7, 8, and 9 in the former article If these two sets of tables are compared it will be noticed again that the subjects in the present

experiment have, as a whole, somewhat better records than those of the former If, however, the boys of this group are compared with the boys of that group, and the girls with the girls, it is evident that the main improvement is on the part of the girls In fact, the boys in this group are slightly poorer in trials and errors than in the former They are better, however, in time The girls, then, it seems have become a great deal better and the boys have become slightly worse This means, of course, that the sex difference which seemed very nearly reliable in the former study has almost disappeared. This is especially true if Tables 4, 5, and 6 are considered to be equally important Table 5, however, probably should be given most consideration for the same reason that Table 2 above was believed to be most important of the first three. Table 5 shows the greatest sex difference of any of the last three tables, but this difference does not approach reliability. It is about as reliable as the difference found to exist between the two mazes in Table 2 All three criteria in Table 5, however, show a difference in favor of the boys, whereas in Tables 4 and 6 time alone shows a difference in favor of the boys.

In Table 7 are combined Tables 5 from the present study and 9 from the former, and in Table 8 are combined Tables 6 from the present study and 8 from the former Tables 6 in the present study and 8 in the former study are the tables from which most subjects have been eliminated The sex difference in Table 7 is almost a certainty, while that in Table 8 ranges in significance from about 94 chances in 100 for trials to 99 7 for time. The significance for errors is 98 chances in 100. These two tables, then, indicate an actual though not a completely reliable statistical sex difference in favor of the boys.

TABLE 7

COMPARISON OF SEXES

	95 boys Mean	95 boys σ	103 girls Mean	103 girls σ	σ_{diff}	$\frac{\text{Diff}}{\sigma_{diff}}$
Trials	15 54	9 50	19 28	12 19	1 54	2 43
Errors	34 26	20 18	43 62	26 59	3 34	2.80
Time	542.92	336.49	734 23	444 50	55.77	3.43

TABLE 8

	93 boys Mean	93 boys σ	96 girls Mean	96 girls σ	σ_{diff}	$\frac{\text{Diff}}{\sigma_{diff}}$
Trials	15 04	8.85	17 10	9.11	1.31	1.58
Errors	33.05	18 62	38 88	20 10	2 82	2 08
Time	537 46	332.73	669 73	339.00	48 86	2 71

Intelligence

Intelligence has not proven to be a factor of great importance in maze studies in which college students were used as subjects Hunter (1), Warden (8), Koch (2), Scott (4), Lumley (3), and others have found this to be true The correlations between psychological tests and maze scores are positive, as a rule, but are low, ranging through the 30's, 40's, and occasionally into the 50's The main reasons for these low correlations possibly are, first, that the mazes used are rather crude measuring devices, and, secondly, that college students are a highly select group Of course, however, as Spence and Townsend (7) have found, intelligence becomes a more important factor in maze running if the subjects, even in as select a group as college students, are chosen from the two extremes of intelligence found there. Some of their correlations for a small group of subjects ran into the 60's

Most of the 203 subjects used in these two experiments took some form of the Ohio State Psychological Test In the following tables is found a comparison of the different maze and sex groups in terms of the average of the percentile rankings of the students who took this test. In both experiments the authors did not know what the subjects' scores were on the psychological test until after they had learned the mazes, so no attempt was made to match subjects in any two groups according to ability.

TABLE 9

Comparison of Subjects Who Learned Finger and Stylus Mazes

Finger maze—100 S's out of 104 in both experiments averaged 52 09 on test
Stylus maze— 90 S's out of 99 in both experiments averaged 59 23 on test

TABLE 10

Comparison of Subjects in Former and Present Experiments

Former experiment—94 S's out of 100 averaged 55 29 on test.
Present experiment—96 S's out of 103 averaged 55 66 on test

TABLE 11

Comparison of Sexes

Men	—96 out of 99 averaged 52 73 on test
Women	—94 out of 104 averaged 58 28 on test

TABLE 12

Comparison of Men with Men and Women with Women

Men	—1st experiment	—45 out of 48 averaged 52 93 on test
Men	—2nd experiment	—51 out of 51 averaged 52 55 on test
Women	—1st experiment	—49 out of 52 averaged 57 45 on test
Women	—2nd experiment	—45 out of 52 averaged 59 18 on test

Table 9 indicates that the subjects learning the stylus maze scored somewhat higher than those who learned the finger maze This difference was much greater in the former than in the present experiment, yet the comparisons of the two mazes were practically the same in the two experiments.

Table 10 shows that the level of ability of students used in the two experiments was about the same. In addition, Table 12 shows that both men and women in the present experiment were of about the same ability as in the former It does show, however, along with Table 11, that the women average higher than the men on these psychological tests And since the men, as a whole, are better maze subjects than the women, intelligence as a factor of major importance would seem necessarily to be ruled out. In fact, intelligence would not seem to have been a factor of any great importance in any of the comparisons offered in Tables 9, 10, 11, and 12

Sex of Experimenter

Whether the sex of the experimenter is a factor in the maze-running ability of students is a question which cannot be answered positively from the evidence at hand Whatever answer is given in this discussion must be given in terms of how the sex of the experimenter affects the significance of the sex difference of the subjects in maze-learning ability If Table 5 of the present experiment is compared with Table 9 of the former, we find that a woman experimenter reduces the chances of there being a significant sex difference in favor of the boys in terms of trials from 99 5 chances in 100 to 77; in errors, from 99 9 to 83, and in time, from 100, or certainty, to 96 And if Table 6 in the present experiment is compared with Table 8 in the former, a woman experimenter changes the chances of the boys' being superior in terms of trials from 98 4 for boys to 62 in favor of girls; in errors, from 99 5 for boys to 52 in favor of girls; and in time, from 99 9 to 80 both in favor of boys Table 6 in the present and Table 8 in the former experiment are the tables from which most subjects have been eliminated

Some slight evidence in regard to the effect of the sex of the experimenter may be obtained from a consideration of the sex of the subjects in the two experiments who seemed most eligible for elimination Of the four in the former experiment, an experiment in which men were the experimenters, three were girls and the one boy who was eliminated was not eliminated because of any undue emotionality, but because of sheer stupidity On the other hand, the three subjects who were most eligible for elimination in the present experiment, an experiment in which women were the experimenters, were boys. And two of the next three or four most eligible ones were boys also

More evidence in regard to the presence of an actual sex difference in maze-running ability and in regard to the effect of the sex of the experimenter has been obtained by Scott and Henninger (5) (men) in a com-

parable maze situation in which 27 male and 23 female college students acted as subjects The sex difference found was practically the same as that found by Scott and Nelson The boys were superior throughout. The significance of difference for trials was 97 chances out of 100, for errors 98, and for time 99.6 That this superiority of the boys once more was not due to a greater level of ability as measured by psychological tests is indicated by the fact that the average centile for the boys was 42 while that for the girls was 54 This superiority of the boys has shown up in two groups which substantiate each other and total 150 subjects This leads one to believe that there is an actual though not statistically reliable sex difference That this superiority of the boys, however, is much less evident, or, in fact, has just about disappeared in another group of 103 subjects in which the experimenters were women, is evidence that the sex of the experimenter is a factor in maze-running ability

SUMMARY

1. Four women experimenters, using 103 S's (51 boys and 52 girls), found practically the same slight trial-and-error difference in favor of the finger maze and about the same time difference in favor of the stylus maze as were found by Scott and Nelson.

2. Sex differences have almost disappeared except in Table 5, where they are not reliable However, when the results of two of the three sex tables in the present study are combined with those of similar tables in the former, sex differences in favor of the boys approach practical certainty in significance (Tables 7 and 8). The same is true of sex differences in a third study cited, in which men were the experimenters

3 The fact that the girls in the present study were much better and the boys were slightly worse than the respective sex groups in the former study is offered as evidence that the sex of the experimenter is a factor in maze-learning ability Further slight evidence of this may be obtained from the fact that three of the four worst subjects in the former experiment were girls and five of the seven or eight worst ones in the present experiment were boys

4 Intelligence as a major factor in maze-learning ability is ruled out by the fact that in all three experiments cited, in which 253 subjects were used, the girls averaged higher on the psychological test and yet had poorer maze records than the boys

REFERENCES

1. HUNTER, W. S, & HERON, W T. Studies of the reliability of the problem box and the maze with human and animal subjects *Comp Psychol Monog*, 1922, 1, No 1 Pp 56
2 KOCH, H L, & UFKESS, J. A comparative study of stylus maze learning with blind and seeing subjects. *J Exper. Psychol*, 1926, 9, 118-131

3. LUMLEY, H L. An investigation of the responses made in learning a multiple choice maze. *Psychol Monog*, 1931, **42**, No 189. Pp 61

4. SCOTT, T. C The retention and recognition of patterns in maze learning *J. Exper. Psychol*, 1930, **13**, 164-207.

5. SCOTT, T C, & HENNINGER, L. L. An unfinished study of motivation in maze learning. (Unpublished)

6. SCOTT, T C., & NELSON, B B Factors affecting the reliability of the maze: a comparison of the high-relief finger maze and an improved form of the stylus maze *J Gen Psychol*, 1932, **6**, 70-89.

7. SPENCE, K W, & TOWNSEND, S. A comparative study of groups of high and low intelligence in learning a maze *J Gen. Psychol*, 1930, **3**, 113-130

8. WARDEN, C J The relative economy of various modes of attack in the mastering of a stylus maze *J Exper Psychol.*, 1924, **7**, 243-275

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A CONVENIENT UNIT FOR A VARIABLE ANIMAL MAZE

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The need for a variable maze is frequently felt by anyone doing extensive work with maze problems Such a maze is sometimes desirable for human subjects, but it is especially so for animals Various mazes of this kind have been described and, without attempting to be at all exhaustive, we may divide them into three types (*a*) mazes which are built up of wall-units, as described by Gengerelli (1) and Valentine (5), (*b*) mazes which are composed of compartment-units, as illustrated by the Columbia maze (6), the maze described by Liggett (2), and the inclined-plane maze designed by Ruch (4), and (*c*) mazes which are made up of elevated units, as described by Miles (3).

The maze herein described is of the wall-unit type It has been used in the University of Oklahoma Laboratory for the past two years and has proved quite satisfactory

The wall-unit The unit used in constructing the walls may be cut from any kind of wood which will not warp Bass-wood is best, but white pine is very satisfactory The dimensions of the unit depend upon the depth of the maze and the length of segments in runways and culs-de-sac desired The Oklahoma maze is 6" deep with runways 4" wide and of various lengths The unit is a piece of white pine, ½" x 6" x 8", several examples of which are shown in the assembly of Figure 1. (If a larger unit is desired it must be ½" thick but may be as wide and as long as desired, *the length*, however, *should be a multiple of the width of the runway adopted*) A few miscellaneous pieces of 3", 4", and 12" lengths may prove necessary for constructing entrance compartments, food compartments, doors, and the like

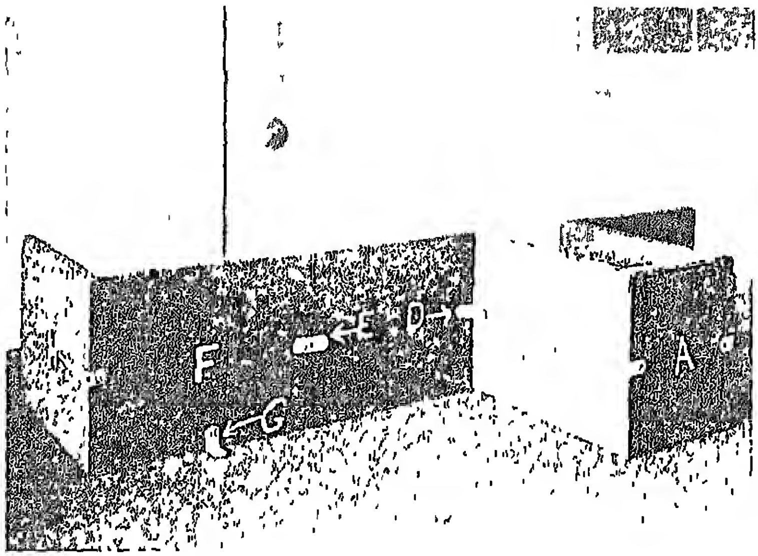

FIGURE 1

Reproduction of an Assembly of Parts Illustrating the Use of a Proposed Wall-Unit in the Construction of a Variable Maze

(See text)

A 5/32" hole is bored at the center of each piece ½" from each end for holding the metal strips which join successive units. If units wider than 6" are needed, it may prove advisable to have two holes at each end to prevent irregularities in alignment. However, if more than one hole is used, the holes should be equally spaced from the sides so that the unit will be reversible, end for end and top for bottom. In preparing the units much care must be taken to get them all exactly the same width and length and perfectly squared at the ends, and to get the holes centered at exactly ½" from each end, at equal distances from the sides and at right angles to the surface.

Perforated strips. The wall-units are joined by perforated metal strips bolted on the outer side. The strips are ½" wide, slightly less than 1/32" in thickness and have 5/32" perforations at ½" intervals. Almost any length from 1" to several inches may be secured but for most mazes the following lengths will be needed: 1" (3-hole) strips for joining two units on a straight-away, hinging doors, making stops for doors, anchoring the walls to the floor, etc.; strips 1½" long (4-hole) for joining units at corners, 7" (15-hole) strips for tying two opposite walls together where there is considerable

strain or pressure which might cause the walls to spread These strips may be secured from the Meccano Company of America, Inc, New Haven, Connecticut, or their distributors

Screws A supply of machine screws, 1/8" x 3/4", with nuts to fit them, is needed in bolting the strips to the wall-units The heads of these screws should be on the inner side of the unit with the nuts against the perforated strips on the outer side. By applying a little force with a flat wrench, the bolts can be drawn up flush with the inner surface of the wall so as to obviate any obstruction within the runway A few flat head ½" wood screws are also needed to secure the perforated strips when used as braces, stops, hinges, anchors, and certain types of corner brace Assorted lengths of wood screws may also be needed for other purposes, depending upon the accessary parts needed

Assembling Most of the details involved in assembling the maze-parts are shown in the accompanying figure The wall-unit is illustrated particularly at *F*. *A* is an entrance door hinged at the top at *B* by means of wood screws passing through the walls at the side and small metal washers which serve as bushings *B* also shows the use of a perforated metal strip for tying two opposite walls together, *C* is a 3-hole metal strip bent at a right angle and secured with a machine screw which serves as a door stop; *D* is a 3-hole strip bent at a right angle and secured with a machine screw and ½" wood screw which joins two units at an inside corner, *E* is a 3-hole strip held by two machine screws and joins two units on a straightaway, *G* is a 3-hole strip bent at a right angle and held in place by two wood screws which anchors the wall to the foundation or floor on which the maze rests, and *H* is a 5-hole strip (though a 4-hole strip will suffice) secured by two machine screws which joins two units at an outside corner

The floor of the maze is the top of the table or platform on which it rests It is usually advisable to fit the runways with strips of linoleum, which facilitate cleaning and give a more uniform running-surface The walls should be anchored to the platform at intervals as was described above

Doors may be of two types, hinged or sliding For a hinged door, a piece of the ½" pine cut to the proper dimensions is satisfactory It may be hinged at the top, bottom, or side by means of metal strips of the proper length and bent at the proper angle, depending upon the relation of the door to the wall which is to support it For sliding doors one may use either a section of the white pine running in grooves shaped from sheet metal or a section of sheet metal running in grooves cut in opposite walls of the maze In either case, it is generally advisable to prevent the sliding door from coming closer than ¼" to the floor so as to prevent pinching the tail of the animal when the door is closed Supports may be erected at the sides of the maze to which pulleys can be attached for operating the sliding doors

The cover of the maze may be either wire netting or glass, with openings for the sliding doors If one so desires, the maze may be 10″ or more in depth, in which case no cover is ordinarily necessary for white rats

The advantages of a maze made up of these units are numerous·

a It can be adapted for use as a labyrinth maze with runways and culs-de-sac as wide, as long, as deep, as devious, and as numerous as desired Almost any two-dimensional pattern can be duplicated It is especially adapted to lateral or longitudinal reversibility, as it can be turned bottom upward (since it has no floor), turned end for end, or knocked down and rebuilt.

b It can be used in the form of a discrimination box and the interchangeability of its parts facilitates the study of various sensory controls

c It is easily cleaned, since the anchors can be released and the whole maze lifted about

d It is very economical, since its initial cost is very low, since it can be assembled by anyone with minimum mechanical experience, and since the units can be used repeatedly in various maze patterns

e. It can be knocked down and the units stacked flat in bundles for storing (As a precaution to prevent warping of the units the bundles should be weighted)

It has at least two disadvantages when compared with some other types of unit maze.

a It is not as strong and rigid as a maze which has its own floor However, after a maze is once set up in place there is usually little need for rough usage and abuse

b More time is needed for assembling than for a maze made of compartment units However, its flexibility greatly outweighs this disadvantage

REFERENCES

1. GENGERELLI, J. A. The principle of maxima and minima in animal learning *J Comp. Psychol.*, 1931, **11**, 199-215.

2. LIGGETT, J. R A convenient sectional maze *J Genet. Psychol.*, 1929, **36**, 469-473

3 MILES, W. R. The narrow-path elevated maze for studying rats *Proc Soc Exper Biol & Med*, 1927, **24**, 454-456

4 RUCH, T C The discrimination ability of albino rats measured by a triple-unit inclined plane apparatus *J Comp. Psychol.*, 1930, **10**, 11-34

5 VALENTINE, W L. A technique in maze construction *J. Comp. Psychol*, 1929, **9**, 197-201

6 WARNER, L H., & WARDEN, C. J The development of a standardized animal maze. *Arch Psychol*, 1927, No. 93 Pp 46

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THE SPEED OF PUPILLARY CONTRACTION IN RESPONSE TO LIGHT IN PIGEONS, CATS, AND HUMANS

RALPH H GUNDLACH

A series of experiments on the problem of homing in pigeons has led to a consideration of some of the characteristics of vision in that bird The sense of sight is indicated, largely by negative evidence, as the chief guide to the homer (Warner, 6, Strong, 5, and Gundlach, 2, 3). If vision is of such importance, its mechanisms we should suspect must be of very high class This proves to be the case with the speed of the pupillary reflexes of the pigeon

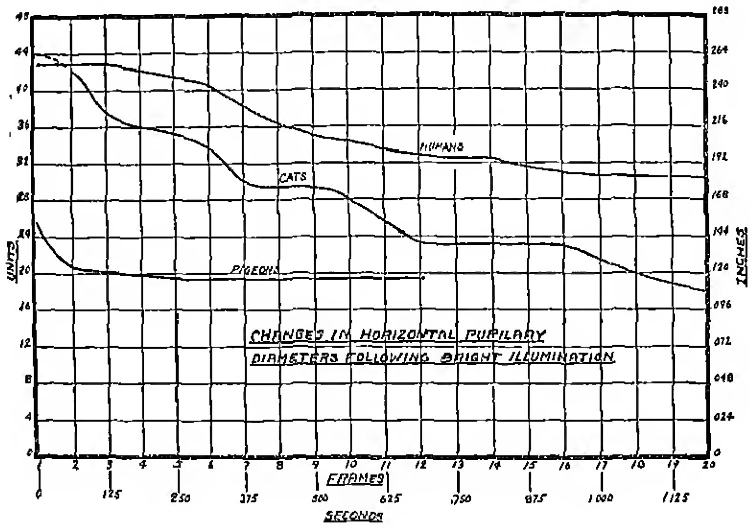

FIGURE 1

The eyes of the various subjects employed were photographed on 16-mm motion-picture film[1] The general procedure consisted in setting up the camera on a table 2 ft from the point where the subject's eye was to be held Two 100-watt lamps were placed on either side of the camera, one 22 in. and the other 28 in from the object The lights were controlled by a silent switch The material was assembled in a room that had no windows The room was not dark, however, as the door was usually left

[1]The camera used was kindly loaned by Professor Gross from the equipment of the Department of Physical Education for Women

partly open No attempt was made to get the eyes totally dark-adapted. The subject's eye would be placed for photographing, the camera would be started, and then the lights would be turned on for some time. A number of exposures with *certain variations in technique were employed with each subject* Since the lights could not be timed accurately with the beginning of an exposure, the first frame of each series usually shows some fractional amount of exposure A slight error in time measurement is thus introduced

Eight light-eyed subjects were used three humans, three pigeons, and two cats The developed film was inspected and the pupillary sizes of the various eyes measured under the microscope The measurements are not perfectly accurate. The representation of the pupil on the film never exceeds 02 in in diameter, and descends to less than one-fifth of that size *The outline of the pupil under the microscope is often blurred and fuzzy*, and in some cases distorted by the image of the reflection from the point sources of illumination The average of several determinations, however, is probably quite accurate. The data for each of the different classes of animals are graphed in Figure 1 The curve for the three human subjects includes 15 exposures There are 26 exposures averaged for the three pigeons, and 7 for the two cats The differences between individuals of the same class were limited almost exclusively to pupillary size *Grouping the subjects makes practically no difference with respect to pupillary change as a function of time A minor* exception will be *mentioned* later

A glance at the curves shows that the eyes of the pigeon are accommodated before the human eye even starts to change The eyes of the cats probably start changing almost immediately, but they continue to adjust at least for 2 sec. after the lights are turned on Let us consider the data for each class of animal in turn.

In 15 of the 26 series with the pigeons, the animals closed apparently *the nictitating membrane (1, 4, 6) Two of these closures occur in the first exposed frame of the series. This indicates a remarkably fast* reaction-time for the muscles controlling this membrane Eight occur in the second frame Three of these are continued into the third frame. The remaining 5 all occur during the exposure of the third frame When the eye is thus "closed" the pupil can still be seen pictured on the film through the membrane, but the outline is too diffuse to measure In many of the frames the pupil of the eye of the pigeon seems oval in shape, at *about a 15-to-18 ratio This may have been due to changes in the axis of vision, but I believe that it represents an actual condition, and one that* can be observed with the unaided eye when a pigeon focuses an object that is near and in front of it The different sets of exposures with the pigeons show a high consistency. Practically none of the measurements of a given pigeon vary as much as 3 units from analogous frames in other series No such reliability occurs either with cats or with humans Further, in 14 of the exposure sets the pupillary accommodation was completed

by the second frame. In the others there were slight changes as far as the third or fourth frame The smallest pupillary size developed when a spot of light from a flashlight was played upon the eye of a pigeon The pupil then measured about 035 to 04 in. in diameter The extreme rapidity and consistency of reaction in the iris of the pigeon may be attributed to the striated character of the muscle. Slonaker has shown that both the iris and the ciliary muscle in the sparrow are striated (4), and this doubtless holds true of the pigeon

Both of the cats, upon their first exposure to the lights, closed and opened their eyes three or four times in the first 2 sec. of photographing This blinking was rare on further exposures, even though the cats struggled a bit to turn away from the lights As with the human subjects, the pupil of the eye was larger on the first series than on the subsequent ones This might be due to residual effects from the preceding exposures, rather than to any practice effects. The more rapidly adapting pigeon's eye would not show residual effects under the conditions of this experiment The iris of the cat at the first frame in each series of exposures is quite round, but becomes oval in 6 to 8 frames The size of the pupil on the first frame of each series could not be well determined because practically all of the exposures had insufficient illumination The first value in the plot for cats is not very reliable Due to the head-turning and squinting, measurements of the vertical extent of the pupil are virtually impossible early in the series, and even the horizontal extents may be slightly in error Two exposures, however, lasted 3 5 and 4 5 sec, and at both the 50th and the 70th frames the pupil had reached a size of 10 units horizontally and 20 vertically (approximately .06 x 12 in.)

For the three human subjects there were in all 15 exposures, and in no case did any blinking or winking show in the film. I do not know that any of the subjects did wink As with the cats, the first series for each subject gave a consistently larger pupil, by about 5 units at all readings for the first 8 to 12 frames Again, like the cats, the two eyes were often uneven in pupillary size. It is to be remembered that the two lights used for illumination were asymmetrically placed Great individual differences in pupillary size occurred with the humans on the first frame of each exposure series, although by the end of 15 or 20 frames the greatest difference was about equal to that between a pair of the pigeons, namely, 5 units.

In conclusion, this investigation shows that the iris of the living pigeon can adapt itself to a sudden and intense increase in illumination in 06 to 12 sec Under the same conditions the human iris does not start to change until after at least 12 sec, and only approaches stability after a full second The iris of the cat starts to react more quickly than that of the human, but continues the process of adaptation much longer

REFERENCES

1 FRIEDMANN, H On the supposed visual function of the nictitating membrane in the domestic pigeon. *J Comp. Psychol*, 1932, **14**, 55-61
2 GUNDLACH, R H A test of "directional sense" in cats and pigeons *J Comp Psychol.*, 1931, **12**, 349-356.
3. ——— A field study of homing in pigeons. *J Comp Psychol*, 1932, **13**, 397-402.
4. SLONAKER, J R. A physiological study of the anatomy of the eye and its accessory parts of the English sparrow (*Passer domesticus*). *J Morphol*, 1918, **31**, 351-459
5 STRONG, R. M On the olfactory organs and the sense of smell in birds *J. Morphol*, 1911, **22**, 619-662
6 WARNER, L H. The present status of the problems of orientation and homing by birds *Quar. Rev Biol*, 1931, **6**, 208-214
7 WOOD, C A. The eyelids and lachrymal apparatus of birds. *J Ophthal*, 1915, **11**, 641-658

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AN ANECDOTE ILLUSTRATING "DISGUST" IN A DOG

RALPH H GUNDLACH

In a test of the James-Lange theory of emotions, Sherrington observed and reported "disgust" on the part of dogs even after transection of the spinal cord when they were offered dog meat (3, pp 261 ff.) Two recent investigators have repeated this phase of Sherrington's work, and both report somewhat different results with normal animals. They find that some dogs will eat dog meat at once, and that all or most others will reject it for a time only; but, further, they find that some of those that reject dog meat also reject other sorts of food Maslow concludes (2) that the emotion of disgust has not been shown in dogs, and Girden concludes (1), in the same vein, that aversion for dog meat is far from uncommon

It appears to me very strange if dogs can generalize the species character of the odor of dog flesh and can recognize it as their own. It seems more plausible to suppose that dogs, as most creatures, become habituated to certain kinds of foods Some material new and strange to the adult may eventually be treated as food, but it may well be treated with considerable diffidence at first. This seems to be the typical behavior of the dogs reported by Maslow and Girden It would have been interesting to try some of the dogs treated in these experiments on dog meat with, say, whale meat, smoked or frozen salmon, snake, or the like The idiosyncrasies of food habits in dogs and cats is a common source of table conversation

Such an idiosyncrasy occasions my story, which, I trust, adequately illustrates the emotion of disgust in a dog I was living one summer on a mountain top in a tent A pack train established me, but replenishments I

had to pack in from a town 8 miles distant. As a consequence I had little meat A young setter pup was with me. He soon grew to dislike much of the food I could provide him His rations consisted of oatmeal and canned milk, and "bannock"—a muffin batter cooked as a big thick pancake—garnished with a little ham or bacon The dog would eagerly await breakfast and would eat his mush at times with some relish, especially if some meat was flaked up in it. But he would not fill up upon such food when the aroma of ham or bacon still filled the air So he would sit and occasionally beg as I ate breakfast. Sometimes I would toss him a morsel The emotion of "disgust" would be amply demonstrated if the morsel turned out to be a good hunk of bannock

The dog would catch the food as I tossed it to him But if it was bannock he would spit it out onto the pine-needle-and-dirt floor Typically, he would then gingerly approach it, and sniff Then he would exhale with considerable vehemence, shake his head, sneeze, wrinkle up his forehead between the ears, the next step would consist in attempts to bury the odor of the bannock That is, he would throw dirt over the food with his paws, or more often with his nose, and then ease up to it to sniff again. But the smell would still be there, and he would snort with a snapping shake of his head and vigorously attempt to bury the pancake again and again Finally, he would give up the attempts at local burial, and reach for the food with his teeth. With lips drawn far back, head extended, nose wrinkled, he would pick up the bite, glance about the tent, and then very carefully, and with a seeming bated breath, march out of the tent and away to a big rock slide There he would drop the cake, again snort (to clear his nose of the odor?), and sometimes he would shake somewhat as a dog does coming out of water Then back to the tent he would come prancing, head and ears and tail up, seeming thoroughly pleased with himself

References

1. Girden, E. S. Cannibalism in dogs *J. Comp Psychol.*, 1932, 14, 409-413.

2 Maslow, A. H. The "emotion" of disgust in dogs. *J. Comp. Psychol*, 1932, 14, 401-408.

3 Sherrington, C S The integrative action of the nervous system New York: Scribner's, 1906 Pp xvi+411

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THE SECOND PSYCHOLOGICAL EXPEDITION TO CENTRAL ASIA*

A. R Luria

The second psychological expedition to central Asia, which took place in the summer of 1932, had for its aim extension of researches which were undertaken by the first expedition in 1931 The fundamental aim was to study those peculiarities of the psyche which are the result of various historical conditions and to trace out the fundamental laws in development of psychological processes In this respect central Asia is of exceptional interest on account of the residuals of primitive economic conditions which are now undergoing tremendous industrial, political, and cultural transformation. This change gives opportunity for studying not only the peculiarities of psychological processes under various conditions but, what is more important, the very dynamics of the transition from the more elementary psychological laws to the more complex processes Just as in the first expedition, the study was undertaken in the region of Uzbekistan in which were especially chosen the more primitive kishlaks districts as far as their economic, cultural, and social conditions were concerned, such as the Kishlaks of Shahimardan and Jordan, and the grazing kirgiz lands in the Altai Mountains, as contrasted with the Kishlaks of Palman with a thorough collectivization, well-developed cultural work, and high industrial organization.

In contradistinction to the first expedition, not only the adults were studied but also the kishlak youth on whom the cultural changes must have made a special impression In the second psychological expedition the following took part

Professor A R. Luria, Director of the Expedition

Professor K Koffka (Smith College, Northampton, Mass)

Professor P I Leventueff of Samarkand

Docent F. I Shemyakin of Moscow

Docent A. I Kaminina of Samarkand

Assistant E H Mordkovich of Moscow, and a group of Research Fellows of the Uzbek State Academy of Education: G Ashrafi Bagautdinov, Mangushova, Nugmanoff, and Ussmanoff

The expedition was organized by the State Psychological Institute of Moscow, the Psychological Section of the Ukrainian Psychoneurological Academy of Kharkov, and the Department of Education of the Uzbek Pedagogical Academy The expedition was also backed by People's Commissariat of Education of the Uzbek Socialist Soviet Republic and the Government of Uzbekistan.

The immediate aim of the expedition consisted in the further study of the system of thinking which is characteristic of primitive societies, the develop-

*Translated from Russian by Dr. J Kasanin and Dr F L Wells

ment of the psychological functions in their thinking, and in the pointing-out of those changes which this thinking undergoes in social and cultural transformation connected with socialistic growth In the account of the first expedition it was shown that in the primitive community life one finds a specific system of thinking which is characterized by its own structure, and by a different rôle which speech takes in it. A fact was noted that the main function of this thinking is not the formation of abstract connection and relationship between symbols, but reproduction of whole situations, whole complexes closely connected with specific life experiences, it was pointed out that separate psychological operations, such as memory, comparison, generalization, and abstraction, are formed in this type of thinking quite differently, and that, with the change of economic conditions this situational or complicated thinking very quickly becomes changed, giving place to other more complex forms of thought. It was the aim of the second expedition to study in more detail the characteristics of the structure of the "situational" thinking and its various functions as well as to study those paths along which the transformation of the situational thinking takes place by the development of thought into concepts under the influence of such new molding forces as collectivization, cultural development, literature, etc. In this field the following problems were undertaken·

1 *Professor A R. Luria in cooperation with Bagautdinov—The structure of situational thinking and the lines of its modifications.* The work was devoted to two fundamental problems. On one hand, there was an experimental study of the formation of various intellectual functions in situational thinking. The formation of logical conclusions, abstraction, generalization, and classification were studied in a series of experiments, and it was established that all of these have their specific peculiarities which sharply differentiate situational from categorical thinking Being involved in everyday practical life, it operates to a large extent with ready-made things and actual situations rather than conditioned symbols It reproduces more completely the connection between things entering into the general situation instead of the establishment of logical categorical relationships It brings things under the same denominator instead of generalization along definite rules It generalizes by approximating things At the same time, one finds ready steps toward conceptual thinking, which develops very rapidly under the influence of cultural and social stimuli In this development a very important part is played by speech, which receives new intellectual functions

A second problem was the study of the extent to which it is possible to have thinking in isolated compartments not connected with immediate experiences. By a series of experiments it was established that, while reasoning connected with an immediate situation runs through without any difficulties, the same reasoning removed from actual situation and transferred into a purely artificial system becomes extremely labored or altogether impossible, such as, for example, when problems have to be solved in con-

nection with purely artificial setting, etc, or the reductions from the opposite In this respect there was a definite difference in the individuals on different levels of cultural and social development

2. *Professor Kurt Koffka, together with G Ashrafy—Investigation of perception in various historical cultural phases* The following results may be considered as proved: With very few exceptions the men and women examined by us succumbed to the optical illusions—of which a great variety was shown—just as we do Quantitative measurements of the Muller-Lyer and Poggendorf patterns yielded a slightly smaller amount of these illusions than control experiments with European psychologists The exceptions, which were very rare in this expedition, but had been much more frequent in the first, are easily explained by the attitude of the testees towards the experimenter. Naive, social subjects who treated the experimenter on a footing of equality and did not regard the experiment as a test of their ability had the illusion without exception Only when the subjects were suspicious, staring a long time at the patterns before making their judgments, the illusions failed to appear with some though by no means with all patterns, in accordance with well-known facts

Similarly, it could be proved with several very simple figures like Mach's book, Necker's cube, Schroder's staircase, that plane perspective drawings may compel the perception of a tridimensional object. If the pattern is more complex and has greater representative value, the intended tridimensional effect, as a rule, does not appear, although we see these figures as tridimensional. Thus the opposite report of previous investigators can be explained, according to which Uzbeks, not reached by modern culture, cannot perceive perspective

Transformation in the organization of a chess-board pattern was always performed, though sometimes with difficulty The Kohts test manifested great, but not insuperable, difficulties in the abandonment of the originally perceived form *

3 *Professor P Leventueff, together with Assistant Mangushova—Investigation of causative thinking and its historical development.* This problem was started during the first expedition In the second expedition the work began by an attempt to clarify the process of causation in empirical and theoretical thinking, and the function of speech in understanding of causation and to investigate processes involved in understanding of familiar situations as they become broadened into ideas about unfamiliar objects Special experiments were devoted to causation as perceived in situational thinking and the stages of development in the structure of reasoning

4. *Docent F. H Shemyakin, together with Assistant Nugmanoff—The*

*Translator's note These conclusions were sent directly to us by Professor Koffka

understanding of symbols in situational thinking. The research was devoted to the clarifying of how complex meanings are understood in situational (complicated) and perceptual thinking. The investigation included an understanding of comparisons, metaphors, proverbs, and fables with an analysis of the structure of the process of understanding their meaning Difficulties were described which were encountered in complex thinking when the subject is confronted with the problem of understanding of symbolic speech. This investigation points to the fact that in preparing a text for the illiterates, as well as lectures for people living on a primitive cultural level, one must understand the peculiarities of complex thinking, and avoid those expressions which might be misinterpreted in such thinking.

A special "Arbeit" dealt with the appreciation of humor in complex thinking It was learned that the appreciation of humor in complex thinking, as well as in the active technique, contains certain special features As a result of this, it was learned that certain common devices usually employed in making jokes, which are connected with substitution of meanings rather than situations, are beyond reach of certain cultural groups

5 *Assistant E N Mordkovich—The understanding of a poster and its meaning in situational thinking* The problem consisted in the analysis of how the meaning of the poster with its symbolic meanings is understood in complex thinking It was established that a great deal in the symbolic posters was understood differently by the primitive cultural groups than by the urban groups

6 *Docent A. A Ussmanoff, together with E H Mordkovich—Operations of counting in complex thinking* In an investigation of simple operations, which began in the previous expedition, the following problems came up the understanding of numbers and sequence of numbers, the structure of four species in connection with the older counting operations (a scale of 5, and a scale of 20), and the ratios The primitive ways of measuring and counting were studied

The material obtained in the two psychological expeditions to Central Asia established certain peculiarities in the structure of thinking and the special psychological process at various stages of cultural historical development It outlined those lines along which we have the development of psychological processes in a changing environment, largely characterized by ever-increasing economic and industrial complexities Further work in the analysis of this material, as well as a comparison of experiments in the villages as contrasted with the factory, would go on in a special division in the Moscow Psychological Institute devoted to the study of development of the psyche The control investigation of structure of thinking in the disintegration of psychological processes would be concentrated in the division of Normal and Pathological Psychology of the Psychological Sector of the Ukrainian Psychoneurological Academy in Kharkov The further work in

the study of the development of thought in the Uzbek child would be conducted by the Pedagogical Faculty of the Uzbek State Pedagogical Academy in Samarkand The works of the first and second psychological expeditions will be ready for press and prepared for publication by Professor Luria within the next year.

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BOOKS

H. KLUVER *Behavior Mechanisms in Monkeys.* Chicago: Univ Chicago Press, 1933 Pp. xvii+387 $4 00.

The scope of this monograph is much broader than its title might indicate. While it ostensibly deals with the behavior of a small group of monkeys, the monograph actually envisages the whole methodological and theoretical framework of animal psychology. The author introduces a new and somewhat ingenious technique for the investigation of sensory and related processes in primates, a penetrating analysis of certain types of discrimination in monkeys, with special emphasis upon the problem of equivalent stimuli; and a critical examination, in the light of data obtained with monkeys, of such psychological problems as abstraction, generalization, intelligence, relative and absolute reactions, objective and phenomenal properties of stimuli, approximate constancy in perception, and the problem of the "field" and related problems. The emphasis is decidedly *Gestalt,* but not uncritically so Notable features of the author's work are his careful control of factors which might be regarded as extraneous to the problems under investigation and his meticulous reporting of the conditions under which the investigations were carried out.

Most of the experiments involve some form of the "pulling in technique" In a typical situation the monkey is confronted by two or more boxes, each containing a string the end of which is within reach The boxes serve to present stimuli differing in weight, size, shape, color, noise, and the like The animal receives a food reward whenever he pulls in the box containing the correct stimulus When the discrimination had reached a high degree of accuracy several controls to ascertain the influence of extraneous factors such, for example, as relative friction were carried out. If the animal maintained his discrimination throughout these controls, different stimuli were next substituted with a view to determining the nature of the situation governing the responses Other experiments involved a determination of sensory acuity, the ability to use instruments, handedness, the existence of strata functions, and anisotropy

Throughout most of the discrimination experiments, which comprise the most important part of the research, there was considerable constancy of response despite marked changes in the relative and absolute character of the stimuli Although there were a few instances of response to absolute stimuli, a result in conformity with Kohler's well-known results The particular contribution of Kluver along these lines, however, is not so much his observation of the relative nature of primate responses as his analysis of the wide variety of stimuli capable of calling out equivalent responses

Many questions are raised by this analysis and the author fails to answer them Steadfastly refusing to believe that they are unanswerable, however, he puts his faith in future experimental analysis

Although the monograph raises more questions than it answers, certain conclusions are believed by the author to be in order He says, "It must be assumed that the constancy of response is dependent on the existence of such stimulus properties as make heterogeneous stimulus constellations 'identifiable'" This identifiability cannot, however, be explained satisfactorily by resorting to such concepts as generalization, abstraction of identical elements in the various stimulating conditions, or some Strukturfunktion "There is not such a thing as an 'abstraction' per se or a 'generalization' per se or an autochthonous 'Strukturfunktion' The situation remains essentially the same if the 'element' is identified with an objectively existent 'relation' or an objectively existent 'ratio' The independence of the 'relations' from the 'relata' has certain limits Because of the existence of these limits concepts such as 'Strukturfunktion,' 'generalization,' etc, unless properly modified, must be viewed as oversimplifications In formulating 'basic' mechanisms in behavior the particular characteristics of the 'relata' must be given due weight."

The author places considerable emphasis upon such concepts as "interdependence of aspects" and "phenomenal togetherness," but he insists that these concepts cannot receive adequate definition except through detailed experimental analysis of the relation between behavior and the stimulus characteristics upon which it depends "Instead of attempting to find 'exact' but empty laws of behavior we must for a while be content with a cautious 'morphopsychological' stand, that is, with experimentally determining various forms of interdependence"

The experimental data are reported in minute detail, approximately three hundred pages being thus appropriated There are many illustrations, some of them comprising sections of moving picture film. The bibliography includes over three hundred citations

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Books Received

American Psychological Association Year Book, 1934 Pp 182

Bassett, C Mental hygiene in the community New York Macmillan, 1934 Pp 394 $4 50

Fitzgerald, J A, Kelley, V H, Powell, R L, Thisted, M N, Tormey, T J, & Yates, I M Doctoral theses in education I *Univ. Iowa Stud Stud. Educ*, 1934, 9, No. 1 (New Ser, No 267) Pp. 206 $2 00

Garrison, K C The psychology of adolescence. New York Prentice-Hall, 1934 Pp xxii+377 $3 00

Hildreth, G H, & Griffiths, N. L Metropolitan readiness tests for kindergarten and Grade 1 (Ed by J. S Orleans) Yonkers, N Y World Book Co., 1933

Hylan, J C The history of secondary education in York and Oxford counties in Maine (*Univ. Maine Stud*, 2nd ser No 29) *Maine Bull*, 1933, 36, No 5 Pp 78 $ 50

Kandel, I. L The dilemma of democracy (Inglis Lecture, 1934.) Cambridge, Mass. Harvard Univ Press, 1934 Pp 79

Kawin, E Children of preschool age studies in socio-economic status, social adjustment and mental ability, with illustrative cases (*Behav Res Fund Monog*) Chicago Univ Chicago Press, 1934. Pp xxvi+340 $3 50

Mead, C D, & Orth, F. W The transitional public school New York Macmillan, 1934 Pp xxii+371 $2 25

Morgan, J. J B Keeping a sound mind New York: Macmillan, 1934 Pp x+440 $2 00

Myerson, A. Social psychology New York: Prentice-Hall, 1934 Pp xvi+640 $3 50

Rodkey, F S An historical approach to the world problems of today Urbana, Ill., Author, 1934 Pp. 24 $ 25

Symonds, P M Mental hygiene of the school child New York Macmillan, 1934 Pp xii+321 $1 50

Stephens, J. M The influence of the school on the individual Ann Arbor, Mich., Edwards Bros, 1933 Pp iv+106 Lithoprinted

Wallon, H Les origines du caractere chez l'enfant Paris Boivin, 1934 Pp. x+267 24 fr

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GENERALIZATION AND SPECIFICITY OF THE PLANTAR RESPONSE IN NEWBORN INFANTS THE REFLEXOGENOUS ZONE I DIFFERENTIAL SENSITIVITY AND EFFECTOR-SEGMENT PARTICIPATION ACCORDING TO THE AREA OF STIMULATION*[1]

From the Department of Psychology of Ohio State University

KARL C. PRATT

INTRODUCTION

Although the literature upon the plantar response of the neonate is voluminous the significant contributions are limited in number. In brief, the great majority of those who have written concerning this response have contented themselves with notation of the presence or absence of the Babinski reflex A considerable latitude is shown in what is included in the "sign," but usually all responses are disregarded except those of the big toe, and if the movement is extensor in nature the Babinski reflex is reported. Less frequently, extension of the other toes and *signe d'éventail* (fanning) are recorded

It is obvious that this separation of only one element from a response deprives us of the most significant features, namely, the relations between the various segments participating in the response. Such practices tell us little regarding the nature of development in the human organism Those who report the presence of the Babinski sign usually reiterate one of the earliest generalizations, to the effect that since the reflex is *pathological* in adults

*Accepted for publication by Carl Murchison of the Editorial Board and received in the Editorial Office, December 15, 1933

[1]This investigation was completed while the writer was National Research Council Fellow at Ohio State University during 1930-31 Preliminary findings were reported in a paper presented at the meetings of the Midwestern Psychological Association at the University of Chicago in May 1931 The writer takes this opportunity to acknowledge again his obligations to the National Research Council, to the Departments of Psychology and Obstetrics at Ohio State University, to his director, the late Dr A P Weiss, and to his assistants, Mr. Charles Hu and Mr. J Cameron

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with pyramidal tract disturbances or lesions the appearance of this type of plantar response as a *physiological* character in newborn infants is the result of incomplete myelinization of the pyramidal tracts. This interpretation continues to persist because most of the investigators are unacquainted with the epochal studies of Minkowski, Bersot, and others, which show an absence of the Babinski and the presence of a response of normal plantar flexion in the late fetal stages

It is not the aim of this paper to review the history of plantar study Condensed accounts (13, 14) of this field of investigation have been made by the writer, and it will suffice here briefly to sketch the results which have served to delineate the major features of the problem. This will provide the necessary setting for the aims of the present investigation.

Special interest in the plantar response apparently arose from Babinski's (1) original discovery and description of the adult *pathological* response (which now bears his name) and from his subsequently verified prediction that this type of plantar reaction would be *physiological* in infants. We have mentioned in a previous connection the neurological interpretation that has been developed from his studies

Comparative or phylogenetic studies were initiated by Collier (8), who investigated the character of the response in apes and children He noted that in older children during sleep there often occurred a reversion to plantar extension.

Rudolph (15) drew attention to certain parallels between phylogenetic, ontogenetic, and pathological changes in the response to plantar stimulation His work is suggestive but, on account of limited sampling, it is not conclusive.

Burr (6) found insufficient regularity of reaction, in his opinion, to warrant the designation "reflex" This observation was important in that it has served as a corrective to the uncritical conception of the neonate as an organism equipped with highly specific reflexes.

The character of the response during the fetal stages was determined by Minkowski (10) and Bersot (5), the latter tracing the genetic changes in the response throughout the life history of man (4). Bersot undertook to study systematically the total responses to plantar stimulation at different age levels He demonstrated by

statistical methods the variability or spread of effector segments involved and traced the shift in these characteristics with advancing age. Further, the movements of segments were analyzed in terms of the innervated muscles. This series of studies represents a significant step forward in the refinement of (observational) analysis.

It appears that our next attack on this problem should be the combination of Bersot's analytical method with motion-picture records of behavior and with a more effective control of the stimulus The present investigation clearly indicates the need for such procedure. The stimulus control developed by Weiss and his associates (14) and employed in the present research is not sufficiently precise, and the sheer impossibility of obtaining complete observational recordings has been demonstrated convincingly. The stimulating device must effect a better control of the extent of application of the stimulus and of the duration of the stimulus The problem would be greatly simplified if it were possible to apply a punctiform stimulus but there is evidence, according to Carmichael (7), which indicates that responses to point and to stroking contact stimulation may not be the same in all cases The research reported in this paper arose from an earlier verification (14) of part of Bersot's thesis regarding the nature of the response

Since the plantar response seems relatively free from modification induced by environmental stimulation, it is apparent that it furnishes ideal material for studying behavior changes which are dependent upon growth processes

One of the current concepts of the nature of the newborn child holds that from the behavior standpoint he embodies a number of specific reflexes whose subsequent integration into patterns is a function of the environment. Another view holds that normally organisms are always integrated, and that at first there is a total pattern from which reflexes or part activities subsequently are individuated The first view is typified by the Watsonian school, the second by Minkowski, Bersot, and Coghill

If the first hypothesis is correct we should expect to find initially a high incidence in the occurrence of a certain response within a relatively specific reflexogenous zone. If the second is more accurate we should find that at first a response is more generalized

in its receptor-effector relations, and that is becomes "specific" (Bersot) or "individuated" (Coghill) as development proceeds

Bersot's studies (4, 5) indicate that for the plantar response in postnatal life there is a reflexogenous zone which extends over most of the cutaneous surface of the body Stimulation of the customary area, i.e., the median line of the plantar surface, evokes responses which initially include activity in most segments of the body. With advance in age the reflexogenous zone becomes progressively restricted with respect to normal stimuli, and the responses become more and more limited to the member stimulated, with eventual restriction to movements of the big toe. In addition to these changes, a genetic shift from flexion-to-extension-to-flexion is observed.

The Problem

The classification of behavior as "specific" or "generalized" depends upon the point of reference that is used in the cross-sectional or longitudinal planes[2] "Specificity" of behavior rests upon the following criteria: (1) the relative invariability of occurrence of (2) responses relatively localized in particular effector segments and manifesting (3) relatively limited stimulus-receptor-effector relations to action upon receptors or upon receptor areas by (4) stimuli restricted in type and range.

The object of the portion of the investigation treated in this paper is to determine (1) the sensitivity of the area and the frequencies and spread of effector-segment participation in response to stimulation of the *right plantar median,* and (2) to compare these with the sensitivity and the frequencies of effector-segment participation in responses to stimulation of other cutaneous areas of the lower limb, in order that certain limits of the reflexogenous zone or areas of differentiation may be explored. An incidental aim is to ascertain the relative percentage of movements according to type (whether flexor or extensor) of the effector segments of the leg The comparative frequencies of effector-segment *patterns* of response will be treated in a subsequent paper

[2]The writer has attempted in another paper (12) to evaluate and define these terms as descriptive categories in the classification of human behavior from the *genetic* or *developmental* point of view.

TECHNIQUE

The infant is transported in its bassinet from the nursery to the experimental room. There it is divested of its sleeveless gown and is placed upon a low movable padded platform so that the infant's head will be in shadow while the remainder of the trunk is illuminated by the student lamp, which is the only source of illumination in the room The polygraph motor, attached to the experimental chamber or cabinet devised and used by Pratt, Nelson, and Sun (14), is then started in order to operate the timer The experimenter sits on one side of the platform and the recorder at the other Recorder and experimenter check each other's observations of the reactions, but the former does all of the recording on special mimeographed blanks The stimulating device consists of a holder (14) which receives the ordinary hospital applicators which are changed for each infant The infant's leg rests upon the open palm of the experimenter's hand The stimulation is by the usual stroking contact but with a definite limitation of the pressure to about three grams

The following areas are stimulated.

1 the median line of the plantar surface of both feet
2 above heel (tendon Achilles insertion)
3 inner surface of the leg in the region of the knee
4 *top of foot (pedes dorsum)*
5. top of big toe (hallux dorsum)
6 top of little toe (T5 dorsum)
7. top of T2 (T2 dorsum)
8 under big toe (hallux plantar surface)
9. under little toe (T5 plantar surface)
10 under T2 (T2 plantar surface)
11. right plantar mesial border
12 right plantar lateral border

On the average, the time for completion of the experiment is about 15 minutes, distributed as follows.

1. A 2-minute adaptation period after the infant is removed from the bassinet and divested of its sleeveless gown The period is sometimes prolonged until quiescence is attained

2. A 3½- to 4-minute period of stimulation of the 11 selected cutaneous areas

3. A 1-minute rest interval.
4. A $3\frac{1}{2}$- to 4-minute period of alternate stimulation in the median plantar line of the right and of the left foot
5 A 1-minute rest interval.
6 A second $3\frac{1}{2}$- to 4-minute period of stimulation of the 11 cutaneous areas.

The duration of each stimulation is from 1 to 2 seconds and the interval between stimulations is from 15 to 20 seconds, on the average The recorder times the adaptation period, and the experimenter spaces stimuli and rest periods according to the 5-second interval clicks of the timer.

The order of stimulation of the areas is as follows:

1 tendon Achilles insertion
2. hallux dorsum
3. plantar mesial border
4. T2 plantar surface
5 T5 plantar surface
6 T5 dorsum
7. pedes dorsum
8. plantar lateral border
9. hallux plantar surface
10 leg mesial surface
11. T2 dorsum
12. rest period
13. right plantar median
14. left plantar median
15. right plantar median
16. left plantar median
17. right plantar median
18. left plantar median
19. rest period
20. T5 dorsum
21 pedes dorsum
22. plantar lateral border
23. hallux plantar surface
24 leg mesial surface
25 T2 dorsum
26. tendon Achilles insertion

27. hallux dorsum
28. plantar mesial border
29. T2 plantar surface
30. T5 plantar surface

A universal type of record blank makes provision for recording the types of movement in different segments of the body. In actual practice, reliability attaches only to records of movements in the two legs, and there again primarily to the one stimulated. This is because the *number of movements and their time of execution* exceed the capacity of even two observers. Again, in the analysis of data, attention is given principally to two types of movement, the flexion and the extension of a segment. "Fanning" (*signe d'éventail*) of the toes, however, is always recorded because of its frequent inclusion in reports upon the presence of the Babinski response.

RESULTS

In the exploration of the reflexogenous zone of the plantar response, one of the first tests to be made is that of ascertaining the *differential sensitivity* of the cutaneous areas, according to stimulation under the same pressure, time, and areal conditions, so far as the structure of the part will permit. This differential sensitivity may be expressed in terms of *percentage of response.* If the sensitivity of the areas is the *same,* then the percentages of responses to stimulation should closely approximate each other. The same condition would prevail if there were no effective relation between the stimuli employed and the responses that appeared during the experimental period. Differential sensitivity, as expressed in percentage of response, proves that exogenous rather than endogenous factors are operative and that not all cutaneous areas of the lower leg are equally sensitive in regard to initiating activity in that member (Table 3).

An area may be rather sensitive, yet the produced response may be so localized that the number of effector segments participating in the response is limited. Hence a comparison of the number of movements comprising the response offers evidence of the limitation or relative localization of the response. Accordingly, the response to stimulation of the *hallux plantar surface* is more specific than the response to stimulation of the *right plantar median* (Table 3).

In this investigation only the responses noted in the stimulated limb are considered. Further, the analysis, with the exception of fanning of the toes (*signe d'éventail*), is confined to two types of movement, flexion and extension. Further, the gross effector segments are taken to be the thigh, lower leg, foot, and toes. It is realized that this is not a complete picture, but it has proved to be beyond the scope of unaided observation to note the varying participation of movable segments within the toes. That there is such varying participation has been reported by Bersot (5), and the fact was also observed in the present research, but not with sufficient accuracy to warrant its consideration. In this paper, flexion or extension of a toe refers to the general direction of movement of the member whether effected in the distal phalanx or in the proximal phalanges. Even with this limitation it is obvious that the possibilities of toe participation in the response are better than 5 to 1, as compared with any other segment, since a third type of movement ("fanning") is recorded (Table 4). Since these gross, segmental movement values cannot really furnish a true picture of relative segment participation they are equalized (Table 5) by eliminating "fanning of toes" and by reducing the remaining toe movements by 80%. A certain error arises in this procedure, since it equates all toe participation as alike, and certainly that is not the case. Whether a better picture could be obtained by taking the hallux values is a moot question—certainly hallux movements have greater chances of occurring than have movements of any other toe.

An analysis of the differential participation of the toes not only indicates the possibilities of independent representation that we have just mentioned but also throws light upon the effects of stimulation of toe areas as contrasted with foot and leg areas (Table 6).

The type of movement, whether extension or flexion, may be studied from two angles (1) the relative participation of the different effector segments of the leg in the total movements of flexion or extension, and (2) the proportion of extension and flexion in the total movements of a given segment Thus the character of effector-segment movement may be ascertained according to the area of stimulation (Tables 7 and 8). It is possible to make a similar analysis of the character of movements of the different toes (Table 9).

TABLE 1
NUMBER AND DISTRIBUTION OF INFANTS AND OF EXPERIMENTS ACCORDING TO SEX AND RACE OF THE SUBJECTS

	Male		Female		Totals	
	No infants	No expts	No infants	No expts.	No infants	No expts
Negro	6	10	15	34	21	44
White	13	26	21	30	34	56
Totals	19	36	36	64	55	100

Legend *No expts*—number of experimental periods

Table 1 shows that.

1. Of the 55 infants comprising the selection studied, 34 were white and 21 Negro, 36 were female and 19 male

2 Of the 100 experimental periods completed, 44 involved Negroes and 56 whites, 36 involved males and 64 females

TABLE 2
DISTRIBUTION OF EXPERIMENTAL PERIODS ACCORDING TO AGE, SEX, AND RACE

	Negro		White		
Age in hours	M	F	M	F	Totals
0- 24	0	0	0	0	0
24- 48	0	1	1	0	2
48- 72	0	2	2	2	6
72- 96	0	5	2	5	12
96-120	2	3	3	4	12
120-144	3	7	4	5	19
144-168	1	3	3	1	8
168-192	1	3	3	3	10
192-216	0	3	3	5	11
216-240	0	0	2	2	4
240-264	0	3	1	0	4
264-288	2	1	0	0	3
288-312	1	3	1	0	5
360-384	0	0	1	0	1
480-504	0	0	0	2	2
504-528	0	0	0	1	1
Totals	10	34	26	30	100

Legend *M*—male, *F*—female

Table 2 shows that

1 No infants were tested on the day of birth and none beyond the age of 21 days

2. The great majority of the experiments were distributed from the third to the tenth day of life

Table 3 shows that:

1 The plantar surfaces are more sensitive to stimulation by a stroking contact than are the other cutaneous areas of the lower leg Stimulation of the *right plantar median* in 93.5% of the cases releases responses in the stimulated limb, of the *left plantar median* in 94.5% of the cases, of the *mesial* and *lateral plantar borders* in 90.5%, while stimulation of the *pedes dorsum* gives responses in 56%, of the *mesial surface of the leg* in 42.5%, and of *T2 dorsum* in 38.5% of the cases

2 Of the toe surfaces, the *hallux plantar surface* is most sensitive with 68%, and *T2 dorsum* least with 38 5% responses

3. The stimulation in the *pedes dorsum median* (56%) is only a little more than half as effective in releasing responses as in the *right plantar median* (93 5%).

4 The number of effector-segment movements per stimulation is greatest for stimulation of plantar surfaces and least for stimulation of toe surfaces and the inner leg surface Thus the number of movements per stimulation for the *right plantar median* is 5 64, for *plantar mesial border* 4 50, for *plantar lateral border* 4 98, *hallux plantar surface* 1.88, *hallux dorsum* 1 65, *T5 dorsum* 1.83, *T5 plantar surface* 1.63, T2 *dorsum* 1 18, T2 *plantar surface* 1.68 and for *leg mesial surface* 1.47. This index is the resultant of two factors: sensitivity or reactivity, and extent of effector spread or generalization.

5. The number of segments participating per response is the greatest when plantar surfaces and top of foot are stimulated and least when leg and toes are stimulated. Thus there are 6 04 segmental movements per response in the case of stimuluation of the *right plantar median*, of the *plantar mesial border* 4 97, of the *plantar lateral border* 5.50, of *pedes dorsum* 5.28, while *leg mesial surface* gives 3 46 and *hallux plantar surface* 2.77. The greatest specificity or localization of response accordingly is observed when the under surface of the big toe is stimulated.

Table 4 shows that

1. In the gross total of segmental movements the toes pre-

TABLE 3

REACTIVITY AND SEGMENTAL PARTICIPATION OF EFFECTORS ACCORDING TO AREA OF STIMULATION

Area of stimulation	No stim	No res	% res	No S M	S M per stim	D RPM	S M per res	D RPM
Rt plant med	200	187	93.5	1129	5.64		6.04	
L plant med	200	189	94.5	1102	5.51	—0.13	5.83	—0.21
Rt plant mes b	200	181	90.5	900	4.50	—1.14	4.97	—1.07
Rt plant lat b	200	181	90.5	996	4.98	—0.66	5.50	—0.54
Rt hal plant s	200	136	68.0	377	1.88	—3.76	2.77	—3.27
Rt pedes dorsum	200	112	56.0	591	2.95	—2.69	5.28	—0.76
Rt T2 plant s	200	94	47.0	336	1.68	—3.96	3.57	—2.47
Rt tend Ach ins	200	89	44.5	424	2.12	—3.52	4.76	—1.28
Rt T5 dorsum	200	86	43.0	367	1.83	—3.81	4.27	—1.77
Rt leg mes s	200	85	42.5	294	1.47	—4.17	3.46	—2.58
Rt hal dorsum	200	84	42.0	330	1.65	—3.99	3.93	—2.12
Rt T5 plant s	200	80	40.0	327	1.63	—4.01	4.09	—1.95
Rt T2 dorsum	200	77	38.5	237	1.18	—4.46	3.08	—2.96

Legend
Stim—stimuli
Res—responses (reaction in limb stimulated regardless of number of segments involved)
S M—segmental movements, comprising flexion or extension of thigh, lower leg, foot, and all five toes (*signe d'eventail* included)
D—deviation
RPM—right plantar median line
L plant med—left plantar median line
Rt plant mes b—right plantar mesial border
Rt plant lat b—right plantar lateral border
Rt hal plant s—plantar surface of big toe
Rt pedes dorsum—top of foot in median line
Rt T2 plant s—2nd toe plantar surface
Rt tend Ach ins—insertion of tendon of Achilles
Rt T5 dorsum—top of little toe
Rt leg mes s—inner surface of leg at knee
Rt hal dorsum—top of big toe
Rt T5 plant s—plantar surface of little toe
Rt T2 dorsum—top of 2nd toe

TABLE 4

MAJOR SEGMENTAL PARTICIPATION OF THE LIMB STIMULATED

Area of stimulation	Total S M	Total T M	% T M.	Total F M	% F M	Total L M	% L M	Total Th M	% Th M
Rt plant med	1129	926	82 01	141	12 47	41	3 63	21	1 86
L plant. med	1102	896	81 30	144	13 06	44	3 99	18	1 63
Rt plant mes b.	900	656	72 88	159	17 66	55	6 11	30	3 33
Rt plant. lat b	996	793	79 61	159	15 96	32	3 21	12	1 20
Rt hal plant s	377	300	79 57	62	16 47	9	2 38	6	1 59
Rt pedes dorsum	591	484	81 89	81	13 70	20	3 38	6	1 01
Rt T2 plant s	336	272	80 95	47	13 98	10	2 97	7	2 08
Rt tend Ach ins	424	332	78 30	57	13 44	24	5 66	11	2 59
Rt T5 dorsum	367	311	84 74	44	11 98	7	1 90	5	1.36
Rt leg mes s	294	177	60 20	40	13 60	51	17 34	29	9 86
Rt hal dorsum	330	276	83 63	42	12 72	7	2 12	5	1 51
Rt T5 plant s	327	261	79 81	51	15 59	10	3 05	5	1 52
Rt. T2 dorsum	237	194	81 85	37	15 65	4	1 68	2	0 84

Legend

S M—segmental movements, comprising flexion or extension of thigh, lower leg, foot, and all five toes (*signe d'éventail* included)

T M—toe movements

F M—foot movements

L M—leg movements

Th M—thigh movements

Areas of stimulation—same as in Table 3

TABLE 5

Equalized Major Segmental Participation of the Limb Stimulated

Area of stimulation	Total S M	Total T M	% T M	Total F M	% F M	Total L M	% L M	Total Th M	% Th M
Rt plant med	356	153	42 97	141	39 60	41	11 51	21	5 89
L plant med	350	144	41 14	144	41 14	44	12 57	18	5 14
Rt plant mes b	351	107	30 48	159	45 29	55	15 66	30	8 54
Rt plant lat b	328	125	38 10	159	48 47	32	9 75	12	3 65
Rt hal plant s	135	58	42 96	62	45 92	9	6 66	6	4 44
Rt pedes dorsum	187	80	42 78	81	43 31	20	10 69	6	3 20
Rt T2 plant s	112	48	42 85	47	41 96	10	8 92	7	6 25
Rt tend Ach ins	144	52	36 11	57	39 58	24	16 66	11	7 63
Rt T5 dorsum	109	53	48 62	44	40 36	7	6 42	5	4 58
Rt leg mes s	151	31	20 52	40	26 49	51	33 77	29	19 20
Rt hal dorsum	102	48	47 05	42	41 17	7	6 86	5	4 90
Rt T5 plant s	112	46	41 07	51	45 53	10	8 92	5	4 46
Rt T2 dorsum	80	37	46 25	37	46 25	4	5 00	2	2 50

Legend

Same as Table 4 but with fanning of toes (*signe d'eventail*) excluded and with total toe movements divided by 5 to make possibilities of movement comparable to the other segments

dominate, ranging from 84 74% when *T5 dorsum* is stimulated, to 60.20% when *leg mesial surface* is stimulated

2. Foot movements account for the next highest frequency of participation, ranging from 17 66% when the *plantar mesial border* is stimulated to 11.98% when *T5 dorsum* is stimulated.

3 The leg movements come next, ranging from 17 34% when *leg mesial surface* is stimulated to 1.68% when *T2 dorsum* is stimulated.

4. The thigh movements occur with least frequency, ranging from 9 86% when *leg mesial surface* is stimulated to 0 84% when *T2 dorsum* is stimulated.

Table 5 shows that·

1. When the toes are equated as one total segment, the total reactions for the toe values and foot values are approximately the same for all areas stimulated.

2. Leg movements are most frequent when *leg mesial surface* is stimulated, giving 33 77%, while the foot accounts for 26 49%, toes 20.52%, and thigh 19 20%.

3. Movements of the leg occur about twice as frequently as movements of the thigh

4. Movements of toe and foot segments occur about 8 times as frequently as movements of the thigh.

Table 6 shows that:

1. When results from stimulation of all cutaneous areas are totaled, movements of the hallux occur most frequently, with decreasing percentage of participation of each successive toe towards T5 Thus the hallux accounts for 22 89% of all toe movements, T2 for 20.92%, T3 for 20 21%, T4 for 19.54%, and T5 for 16 34%.

2. When the *hallux plantar surface* is stimulated, the hallux accounts for 41 72% of all toe movements; when the *hallux dorsum* is stimulated, only 25.31%

3. When *T5 plantar surface* is stimulated, activity in that member accounts for 14 28% of toe movements, with participation of T4 21.64%, T3 22 07%, and hallux 20.34%, when *T5 dorsum* is stimulated, T5 accounts for 16.16% and hallux for 18 04% of toe movements

TABLE 6

DIFFERENTIAL PARTICIPATION OF TOES

Area of stimulation	Total T M	Total Hal	% Hal	Total T2	% T2	Total T3	% T3	Total T4	% T4	Total T5	% T5
Rt plant med	766	174	22 71	157	20 49	154	20 10	147	19 19	134	17 49
L plant med	721	167	23 16	145	20 11	143	19 83	142	19 69	124	17 19
Rt plant mes b	536	120	22 20	109	20 33	107	19 96	104	19 40	96	17 91
Rt plant lat b	623	127	20 38	129	20 70	130	20 86	127	20 38	110	17 65
Rt hal plant s	290	121	41 72	51	17 58	43	14 82	42	14 48	33	11 37
Rt pedes dorsum	399	65	16 29	91	22 80	88	22 05	85	21 30	70	17 54
Rt T2 plant s	242	69	28 51	52	21 48	46	19 00	44	18 18	31	12 80
Rt tend Ach ins	262	53	20.22	58	22 13	57	21 75	54	20 61	40	15 26
Rt T5 dorsum	266	48	18 04	58	21 80	61	22 93	56	21 05	43	16 16
Rt leg mes s	157	34	21 65	33	21 01	32	20 38	31	19 74	27	17 19
Rt hal dorsum	241	61	25 31	50	20 74	48	19 91	45	18 67	37	15 35
Rt T5 plant s	231	47	20 34	50	21 64	51	22 07	50	21 64	33	14 28
Rt T2 dorsum	184	40	21 73	46	25 00	38	20 65	34	18 47	26	14 13
Totals	4918	1126	22 89	1029	20 92	998	20.21	961	19 54	804	16 34

Legend
T M—toe movements
Hal—hallux or big toe
T5—little toe

TABLE 7

PERCENTAGE OF EQUALIZED MAJOR SEGMENTAL PARTICIPATION IN MOVEMENTS OF FLEXION AND EXTENSION

Area of stimulation	x or fl	Total S M	Total T M	% T M	Total F M	% F M	Total L M	% L M	Total Th M	% Th M
Rt plant med	x	111	102	91 89	6	5 40	3	2 70	0	0 00
	fl	245	51	20 81	135	55 10	38	15 51	21	8 57
L plant med	x	108	100	92 59	5	4 62	3	2 77	0	0 00
	fl	242	44	18 18	139	57 43	41	16 94	18	7 43
Rt plant mes b	x	90	78	86 66	8	8 88	3	3.33	1	1 11
	fl	264	32	12 12	151	57 19	52	19 69	29	10 98
Rt plant. lat b	x	118	108	91 52	6	5 08	4	3 38	0	0 00
	fl	209	16	7 65	153	73 20	28	13 39	12	5 74
Rt hal plant. s	x	36	32	88 88	3	8 33	1	2 77	0	0 00
	fl	99	26	26 26	59	59 59	8	8 08	6	6 06
Rt pedes dorsum	x	68	62	91 17	3	4 41	2	2 94	1	1 47
	fl	119	18	15 12	78	65 54	18	15 12	5	4 20
Rt T2 plant s	x	37	33	89 18	4	10 81	0	0 00	0	0 00
	fl	75	15	20 00	43	57 33	10	13 33	7	9.33
Rt tend Ach ins	x	54	48	88 88	1	1 85	4	7 40	1	1 85
	fl	91	5	5 49	56	61 53	20	21 97	10	10 98
Rt T5 dorsum	x	44	44	100.00	0	0 00	0	0 00	0	0 00
	fl	65	9	13 84	44	67 69	7	10 76	5	7 69
Rt leg mes s	x	37	24	64 86	6	16 21	7	18 91	0	0 00
	fl	111	7	6 30	31	27 99	44	39 63	29	26 18
Rt hal dorsum	x	36	33	91.66	2	5 55	1	2 77	0	0 00
	fl	66	15	22.72	40	60 60	6	9 09	5	7 57
Rt. T5 plant s	x	41	36	87 80	3	7 31	2	4 87	0	0 00
	fl	71	10	14 08	48	67 60	8	11 26	5	7 04
Rt T2 dorsum	x	31	29	93 54	1	3 22	1	3 22	0	0 00
	fl	48	7	14 58	36	75.00	3	6 25	2	4 16

Legend *x*—extension, *fl*—flexion

4. When *T2 plantar surface* is stimulated, activity in the member is 21.48%, hallux 28 51%, T3 19 00%, T4 18.18%, and T5 12 80% of total toe movements, when *T2 dorsum* is stimulated, the activity is distributed as follows: hallux 21.73%, T2 25 00%, T3 20 65%, T4 18.47%, and T5 14.13%

5 When the *right plantar median* is stimulated, the participation is as follows: hallux 22 71%, T2 20 49%, T3 20 10%, T4 19 19%, and T5 17.49%

6 When the *pedes dorsum* is stimulated, the participation is as follows: hallux 16 29%, T2 22.80%, T3 22 05%, T4 21.30%, and T5 17 54%.

7 When the *tendon Achilles insertion* is stimulated, the values are hallux 20 22%, T2 22.13%, T3 21 75%, T4 20 61%, and T5 15 26%.

8 When the *leg mesial surface* is stimulated, the participation is hallux 21 65%, T2 21 01%, T3 20.38%, T4 19.74%, and T5 17 19%

Table 7 shows that:

1. With the exception of the *leg mesial surface,* of the areas stimulated the segmental participation in movements of extension was as follows toe approximately 90%, foot, leg, and thigh taking the remainder decreasing in the order named, with movement in the last segment seldom occurring.

2. When the *leg mesial surface* is stimulated, toe movements account for 64 86%, foot 16 21%, and leg 18.91% of the total movements of extension.

3 With the exception of the *leg mesial surface,* of the areas stimulated segmental participation in movements of flexion was as follows. foot approximately 60%, toes and leg next, and thigh least of all

4 When the *leg mesial surface* is stimulated, toe movements account for 6 30%, foot 27 99%, leg 39 63%, and thigh 26.18% of total movements of flexion

5 When the *tendon Achilles insertion* is stimulated, the participation in movements of flexion is toe 5 49%, foot 61.53%, leg 21 97%, and thigh 10.98%

6 Stimulation of toe areas results in few flexions of leg and thigh

TABLE 8

PERCENTAGE OF FLEXION AND EXTENSION IN EQUALIZED MAJOR SEGMENTAL MOVEMENTS

Area of stimulation		Total T M	% T M	Total F M	% F M.	Total L M	% L M	Total Th M	% Th M
	Total	153		141		41		21	
Rt plant med	x	102	66.66	6	4 25	3	7 07	0	0 00
	fl	51	33 33	135	95 74	38	92 68	21	100 00
	Total	144		144		44		18	
L plant med	x	100	69 44	5	3 47	3	6 81	0	0 00
	fl	44	30 55	139	96.52	41	93 18	18	100 00
	Total	110		159		55		30	
Rt plant mes b	x	78	70 90	8	5 03	3	5 45	1	3 33
	fl	32	29 09	151	94 96	52	94 54	29	96 66
	Total	124		159		32		12	
Rt. plant lat b	x	108	87 09	6	3 77	4	12 50	0	0 00
	fl	16	12 90	153	96 22	28	87 50	12	100 00
	Total	58		62		9		6	
Rt hal plant. s	x	32	55 17	3	4 83	1	11 11	0	0 00
	fl	26	44 82	59	95 16	8	88 88	6	100 00
	Total	80		81		20		6	
Rt pedes dorsum	x	62	77 50	3	3 70	2	10 00	1	16 66
	fl	18	22 50	78	96 29	18	90 00	5	83 33
	Total	48		47		10		7	
Rt. T2 plant s	x	33	68 75	4	8 51	0	0 00	0	0 00
	fl	15	31.25	43	91 48	10	100 00	7	100 00
	Total	53		57		24		11	
Rt tend Ach ins	x	48	90 56	1	1 75	4	16 66	1	9 09
	fl	5	9 43	56	98 24	20	83 33	10	90 90

Legend Same as in Table 7

TABLE 8 (*continued*)

		Total T M	% T M	Total F M	% F M.	Total L M	% L M	Total Th M	% Th M
Rt T5 dorsum	Total	53		44		7		5	
	x	44	83 01	0	0 00	0	0 00	0	0 00
	fl	9	16 98	44	100 00	7	100 00	5	100 00
Rt leg mes s	Total	31		37		51		29	
	x	24	77 41	6	16 21	7	13 72	0	0 00
	fl	7	22 58	31	83.78	44	86 27	29	100 00
Rt hal dorsum	Total	48		42		7		5	
	x	33	68 75	2	4 76	1	14 28	0	0 00
	fl	15	31 25	40	95 23	6	85 71	5	100 00
Rt T5 plant s	Total	46		51		10		5	
	x	36	78 26	3	5 88	2	20 00	0	0 00
	fl	10	21 73	48	94 11	8	80 00	5	100 00
Rt T2 dorsum	Total	36		37		4		2	
	x	29	80 55	1	2 77	1	25 00	0	0 00
	fl	7	19 44	36	97 29	3	75 00	2	100 00

TABLE 9

PERCENTAGE OF FLEXION AND EXTENSION IN TOE MOVEMENTS

Area of stimulation		Total Hal	% Hal	Total T2	% T2	Total T3	% T3	Total T4	% T4	Total T5	% T5
Rt. plant. med	Total	174		157		154		147		134	
	λ	130	74 71	103	65 60	99	64 28	93	63 26	85	63 43
	fl	44	25 28	54	34 39	55	35 71	54	36 73	49	36 56
L plant med	Total	167		145		143		142		124	
	x	128	76 64	99	68 27	96	67 13	94	66 19	82	66 12
	fl	39	23 35	46	31 72	47	32 86	48	33 81	42	33 87
Rt. plant. mes b	Total	120		109		107		104		96	
	x	86	71 66	78	71 55	76	71 02	72	69 23	66	68 75
	fl	34	28 33	31	28 44	31	28 97	32	30 76	30	31 25
Rt. plant lat b	Total	127		129		130		127		110	
	x	110	86 61	113	87 59	114	87 69	112	88 18	93	84 54
	fl	17	13.38	16	12.40	16	12 30	15	11 81	17	15 45
Rt hal plant s	Total	121		51		43		42		33	
	x	77	63 63	26	50 98	21	48 83	22	52 38	14	42 42
	fl	44	36 36	25	49 01	22	51 16	20	47 61	19	57 57
Rt pedes dorsum	Total	65		91		88		85		70	
	x	44	67 69	73	80 21	70	79 54	68	80 00	55	78 57
	fl	21	32 30	18	19 77	18	20.45	17	20 00	15	21 42
Rt. T2 plant s	Total	69		52		46		44		31	
	x	58	84 05	33	63 46	28	60 86	27	61 36	20	64 51
	fl	11	15 92	19	36 53	18	39 13	17	38 63	11	35 48
Rt tend Ach ins	Total	53		58		57		54		40	
	x	44	83 01	55	94 82	53	92 98	50	92 59	36	90 00
	fl	9	16 98	3	5 17	4	7 01	4	7 40	4	10 00

Legend Same as in Tables 6 and 8

TABLE 9 (*continued*)

Area of stimulation		Total Hal	% Hal	Total T2	% T2	Total T3	% T3	Total T4	% T4	Total T5	% T5
Rt T5 dorsum	Total	48		58		61		56		43	
	x	39	81 25	50	86 20	52	85 24	48	85 71	32	74 41
	fl	9	18 75	8	13 79	9	14 75	8	14 28	11	25 58
Rt leg mes s	Total	34		33		32		31		27	
	x	27	79 32	26	78 78	25	78 12	24	77 41	20	74 07
	fl	7	20 58	7	21 21	7	21 87	7	22 58	7	25 92
Rt hal dorsum	Total	61		50		48		45		37	
	x	46	75 40	34	68 00	31	64 58	30	66 66	23	62 16
	fl	15	24 59	16	32 00	17	35 41	15	33 33	14	37 83
Rt T5 plant s	Total	47		50		51		50		33	
	x	40	85 10	38	76 00	39	76 47	38	76 00	24	72 72
	fl	7	14 89	12	24 00	12	23 52	12	24 00	9	27 27
Rt T2 dorsum	Total	40		46		38		34		26	
	x	32	80 00	38	82 60	30	78 94	27	79 41	20	76 92
	fl	8	20 00	8	17 39	8	21 05	7	20 58	6	23 07

Table 8 shows that:

1 In the activity of the toes extension accounts for about two-thirds of all movements

2 In the activity of the foot flexion accounts for about 95% of all movements.

3 In the activity of the leg flexion accounts for about 90% of all movements.

4 In activity of the thigh flexion accounts for about 100% of the movements.

Table 9 shows that.

1 Among hallux movements the percentage of movements of extension ranges from 86 61% when the *plantar lateral border* is stimulated to 63 33% when the *hallux plantar surface* is stimulated

2 Among T2 movements the percentage of movements of extension ranges from 94 82% when the *tendon Achilles insertion* is stimulated to 50.98% when *hallux plantar surface* is stimulated.

3 Among T3 movements the percentage of movements of extension ranges from 92 98% when *tendon Achilles insertion* is stimulated to 48 83% when *hallux plantar surface* is stimulated.

4 Among T4 movements the percentage of movements of extension ranges from 92 59% when the *tendon Achilles insertion* is stimulated to 52.38% when the *hallux plantar* surface is stimulated.

5 Among T5 movements the percentage of movements of extension ranges from 90 00% when the *tendon Achilles insertion* is stimulated to 42 42% when the *hallux plantar surface* is stimulated

6. In general, there is a tendency for greatest percentage of extension to be found in hallux movements with progressive decrease through the other toes towards T5 and, conversely, least flexion with hallux and most with T5.

7. When the *hallux plantar surface is stimulated,* there is a tendency for a greater percentage of flexion in all toes

8 When the *tendon Achilles insertion* is stimulated, there is a tendency for a greater percentage of extension in all toes

9 When *T2 plantar surface* is stimulated, hallux extension is much enhanced in comparison to the other toes

10. When *T5 dorsum* is stimulated, extension accounts for 74.41% and flexion 25 58%, when *T5 plantar surface* is stimulated, extension accounts for 72 72% and flexion 27 27%

11. When the *hallux dorsum* is stimulated, extension of the hallux accounts for 75 40% and flexion for 24.59%, when the *hallux plantar surface* is stimulated, hallux extension is 63 63% and flexion 36 36%.

12 When the *T2 dorsum* is stimulated, T2 extension accounts for 82 60%, flexion 17.39%, when the *T2 plantar* surface is stimulated, T2 extension is 63 46% and flexion 36.53%.

13 In general, stimulation of toe areas leads to a greater percentage of movements of toe flexion than does stimulation of plantar areas, top of foot, and above heel.

Summary and Discussion

1 *The Reflexogenous Zone*

Extent In the most generalized phase of the plantar response, Bersot (5) tells us that the reflexogenous zone is coextensive with the cutaneous area of the body and that, even after it becomes restricted (as far as normal intensities are concerned) to the plantar area, more intense stimuli applied elsewhere will still release the response in its most general phase Nevertheless, exploration of the larger reflexogenous or stimulogenous (Coghill) zone in the neonate reveals the existence of secondary zones or areas which are differentiated in such manner as to present more or less varying reactivities

Differential sensitivity If sensitivity is stated in terms of percentage response to stimulation ($R/S \times 100$), some of the cutaneous areas studied in this investigation manifest differential sensitivity (Table 3). Thus the plantar areas are found to be most sensitive (*Rt plantar median* 93 5%, *plantar mesial* and *lateral borders* (90 5%), and *T2 dorsum* (38 5%), *T5 plantar surface* (40 0%) and *hallux dorsum* (42 0%) are least sensitive An intermediate degree of sensitivity is discovered in the following areas, *hallux plantar surface* (68.0%), *pedes dorsum* (56 0%) and *T2 plantar surface* (47 0%).

Among the toe cutaneous areas the *hallux plantar surface* (68 0%) most closely approximates the plantar areas in sensitivity. The toe plantar surfaces, *T5* excepted, appear to be more sensitive than the toe dorsal surfaces. The anomalous position of *T5* in this respect probably has no significance, or it may be due to the effects of transmitted pressure (stimulation of *T5 dorsum*) upon the plantar area

of the foot when the little toe is already in partial contact. Generally speaking, then, sensitivity decreases progressively from the plantar surfaces proximally along the leg Undoubtedly the structural basis for this differential must be the number and character of the receptors per unit area in the various portions of the leg cutaneous area.

If these differences did not exist it would be necessary to conclude that either the receptor-effector connections were the same (complete generalization), or that the responses were the result of constant endogenous factors, unless a suitable control group established the efficacy of the specific exogenous factor.

Segment spread or involvement The degree of segment spread in the response, as expressed in the ratio of segmental movements to responses (*S M /R*), also serves to indicate the differences in *RE* (receptor-effector) hook-up of the different cutaneous areas (Table 3). Responses are most localized, and in that sense "specific," to stimulation of the *hallux plantar surface* (2.77) and most widespread (i e., "generalized") to stimulation of the *plantar median line* (6 04). In general, the *plantar, dorsum pedes, and tendon Achilles insertion* areas manifest the greatest generalization, while the toe areas have greatest specificity Among toe areas it is noticeable that the greatest specificity is found upon excitation of the *hallux* and least upon stimulation of *T5*

Relative percentage of segmental participation The relative percentage of participation in the response of the segments of the leg likewise is altered appreciably upon stimulation of different areas (Table 5). Thus, of the gross effector segments of the leg, the *toe* accounts for 48 62% of all movements when *T5 dorsum* is excited, while the value is only 20.52% when the *leg mesial surface* is stimulated. The range in *foot* participation is from 48.47% when the *plantar lateral border* is excited to 26 46% when the *leg mesial surface* is stimulated. In the *leg* the range is from 33.77% (*leg mesial surface*) to 5 00% (*T2 dorsum*). In the *thigh* it is from 19.20% (*leg mesial surface*) to 2 50% (*T5 dorsum*)

The relative percentage of participation of the different toes also varies with the area of stimulation (Table 6). Activity of the *hallux* is greatest (41 72%) to stimulation of the *hallux plantar surface,* least (16 29%) to stimulation of *pedes dorsum.* Activity in *T2* ranges from 25 00% (*T2 dorsum*) to 17.58% (*hallux plantar surface*). Activity in *T3* ranges from 22 93% (*T5 dorsum*) to

14 82% (*hallux plantar surface*). Participation of *T4* runs from 21 64% (*T5 plantar surface*) to 14 48% (*hallux plantar surface*) Activity in *T5* is greatest (17 91%) to excitation of the *plantar mesial* border and least (11 37%) to stimulation of the *hallux plantar surface*

Character or type of segmental participation. The character of the movement, whether of flexion or extension, depends to a certain extent upon the area which is stimulated (Table 8). When *tendon Achilles insertion* is stimulated, the values are 90 56% extension and 9.43% flexion of the toes, while to stimulation of the *hallux plantar surface* the values are 55 17% and 44 82% respectively. When *T5 dorsum* is stimulated, *foot flexions* amount to 100%, while to stimulation of the *leg mesial surface* the values are flexion 83.78%, extension 16 21%. When *T5 dorsum* and *T2 plantar surface* are stimulated, the *leg flexions* constitute 100% of the limb movements, while to stimulation of the *leg mesial surface leg flexions* are 86.27% Movements of the *thigh* are predominantly flexor with the greatest amount of extension (16.66%) brought about by stimulation of *pedes dorsum*

The character of the movement of the individual toes is likewise altered according to the area stimulated (Table 9). *Hallux extension* is greatest (86 61%) when the *plantar lateral border* is stimulated and least (63 63%) when the *hallux plantar surface* is excited Similarly, the greatest amount of extension of the other toes, *T2* (94 82%), *T3* (92 98%), *T4* (92.59%), and *T5* (90 00%), occurs to stimulation of *tendon Achilles insertion* while the least amount respectively, (50 98%), (48 83%), (52 38%), and (42 42%) occurs to stimulation of the *hallux plantar surface*

2 *Segmental Participation in the Plantar Response*

Relative participation of homolateral limb segments If the toe segments are made equivalent with all the limb segments studied (namely, the thigh, leg, foot, and toe—treated in this work as though it were one segment—Table 5), in mathematical possibility of participation, the last-mentioned segments participate about equally in the response, with the leg much less represented, and the thigh still less This fact indicates that the activity tends to occur in those segments which lie nearest the source of stimulation This tendency is further emphasized by the relatively greater participation of leg and thigh segments following stimulation of the *leg mesial surface*

It would be interesting to find whether such altered segment participation also appears in the crossed or contralateral response Such studies should throw considerable light upon the peculiarities of neural organization in man at different age periods

Character or type of participation of effector segments. The limb segments differ from one another in their characteristic movements (Table 8). In this study about two-thirds of the toe responses were found to consist of movements of extension (sometimes termed "dorsiflexion") and one-third of the movements were flexor in nature If an analysis according to age periods were made we should expect, upon the basis of Bersot's (5), Lantuejoul and Hartmann's (9) work, and that of others, that the proportion of movements of flexion would prove to be greater the younger the infant

The movements of the remaining limb segments are overwhelmingly flexor in character. Coupling this fact with that of relative frequency of occurrence, it becomes apparent that the most invariable element of the plantar response at this age period is flexion of the foot Thus from another angle the similar conclusions of Pratt, Nelson, and Sun (14) are confirmed.

Comparison of the participation of the various toes demonstrates that the spread of individuation is from *T5* with least to the *hallux* with most (Table 6) This is confirmed not only by the comparative frequency of active participation within the total plantar response but also by the obvious fact that the hallux is much more likely to be active alone (Babinski in narrowest sense) in the response than is the little toe. Again the response tends to be more localized in the member stimulated when the *hallux* is excited than when the other toes are stimulated

In general, the proportion of movements of extension to movements of flexion is about the same for the different toes, but there is a noticeable trend for movements of extension to decrease from the *hallux* to *T5* and, conversely, for the movements of flexion to increase. This may be interpreted as supporting the view that in man the initial individuation of the toes is one of flexion and that further development tends to limit the response to *hallux extension* According to Bersot's magnificent study (5), extension of all toes may precede individuated extension of the hallux and T2. Mixed types of response, with some toes extending and others

flexing, are to be observed and will be treated in a subsequent paper upon the effector segment *patterns* of the response.

3 *Is the Plantar Response a "Movement of Defense"?*

Babinski's interpretation of the plantar response The French neurologist, Babinski (2, 3), has classed the plantar response as a defense movement involving retreat or withdrawal of the limb and its constituent segments from the source of stimulation. He even interprets flexion of the toes in the adult also to be a movement of defense in the form of a counter-attack[3] Such a teleological conception must break down if it can be shown that whether the result is movement away from or towards the source of stimulation depends upon at least four factors. (1) the area stimulated, (2) the nature of the stimulus, (3) the developmental stage of the organism, and (4) the previous posture of the member stimulated

The influence of age and pathological factors upon the character of movement. Movement of the toes away from the source of excitation, when the *plantar median line* is stimulated, occurs in the adult pathological response (Babinski sign) and in the normal physiological toe extension of the suckling If this is a defense movement of "flight" it is strange that the response during the fetal stage, at birth, and for a period of hours afterwards should be predominately flexor in type In terms of "withdrawal," then, whether the reflex is a movement of defense depends, in normal development, upon the particular age of the individual The purposivist, of course, will argue that movement towards the source

[3]"Mais il est à remarquer qu'à l'état physiologique chez l'homme, l'excitation de plante du pied, qui provoque la flexion des orteils, détermine du même côté la triple flexion du membre inferieur, et il en résulte une quadruple flexion Cette flexion des orteils ne serait-elle pas aussi le témoin d'une réaction ancestrale, ayant apparu toutefois à une période du développement plus avancée que les réflexes de défense dont il a eté précédemment question, période où les orteils servaient de griffe? Cette réaction avait aussi en partie la protection pour but, mais c'était un mode de protection différent de celui qui est réalisé par les réflexes de defense primitifs, il ne s'agit plus d'une fuite localisee, d'une retraite en face d'une offensive, ce mouvement de griffe vis-à-vis d'une agression constitue une contre-offensive, mode de protection d'un ordre plus elevé, on conçoit du reste fort bien qu'un animal cherchant à se defendre combine l'attaque avec la fuite. On saisirait ainsi la quadruple flexion a l'état physiologique la flexion de la cuisse, de la jambe et du pied ressortissant aux réflexes de defense primitifs, la flexion des orteils etant l'expression atavique d'un réflexe de préhension" (3, p 1709)

of stimulation is also defensive in nature because it aims to ward off the stimulating object In the case of toe movements it would be necessary to stress that the defensive features consist in the *intent* rather than in the *efficacy* of the movement as far as toe flexions are concerned! Adequate pushing away or removal of the stimulus source might be effected if there were to be vigorous extension of thigh, leg, and foot segments The tables presenting the results of this investigation show, however, that these segments usually flex and hence are withdrawn from the source of excitation.

The area of stimulation and the character of movement Similarly disconcerting to the purposive conception is the change in the character of movements, whether away from or towards the stimulus, when the area of stimulation is varied Thus, to stimulation of *pedes dorsum median,* instead of "withdrawal" movements of the member stimulated, i.e , extension, the response *continues* to be one of *flexion* which, contrasted to plantar stimulation, now means movement *towards* instead of away from the stimulus.

Similarly, stimulation of the toe dorsal areas still releases extension in the greater part of the cases (Table 9). Turning now to the plantar surfaces of the toes, it is apparent that extension (from this angle withdrawal from the stimulus) still predominates although the relative number of movements of flexion in the toe stimulated increases as compared to stimulation of the other areas—and this means movement towards the stimulus It may well be that the conditions of stimulation here determine the character of the response. Carmichael (7) cites work of his own and of Richter to the effect that intense stimuli result in withdrawal movements while weaker stimuli induce movements of approach. In this research punctiform stimulation was not employed and the extent of the stroking contact stimulation was necessarily limited by the size of the parts stimulated

The effect of repetition of the stimulus upon the character of movement The Shermans (16) and others have reported that the character of the toe responses changes upon repetition of the stimulus If the first response of the toes consists of extension, repetition alters it to flexion. Here, obviously, the already-existing posture of the segments must be taken into account

Although the legs are characteristically flexed at knee and hip, the usual consequence of stimulation is still greater flexion of those

segments regardless of the areas stimulated. Flexion, although reduced in frequency, continues to dominate in the response to stimulation of the *leg mesial surface,* although it now means sustained contact rather than removal from the stimulus Similar behavior to "cold" stimulation of the same area has been reported by Pratt, Nelson, and Sun (14). This is in marked contrast to the movements in the Moro reflex wherein these segments first extend and then flex again

The structure of the organism and the type of movement It is evident that the teleological conception of the plantar response cannot be maintained satisfactorily when the history, nature of the reflexogenous zone, and the conditions of stimulation are adequately investigated. It is also questionable whether a classification of movements in terms of withdrawal or approach to stimuli has any value once it is shorn of teleological meaning and made purely descriptive. Apparently the type of movement is determined primarily by the nature of the structures participating in the response This alone can explain behavior which, considered teleologically, would be inexplicably inconsistent.

An examination of other alleged "defense movements" will probably reveal nothing intrinsically purposive in their character.

4. *Symmetry*

Bilateral symmetry of homolateral patterns involved in stimulation of the plantar median areas In its most generalized phase the reflexogenous zone of the plantar response extends over the cutaneous area of the body. Within this larger area secondary zones of differentiation occur and presumably there is a bilaterally symmetrical distribution of these. Certainly the later trend toward restriction of the zone to the plantar areas, when stimuli of usual intensity are employed, is symmetrical.

In this research the only cutaneous area stimulated in both of the inferior limbs was the *plantar median line* Since the study was limited to the homolateral reactions nothing can be stated concerning the contralateral reactions. In the matter of sensitivity there is probably no significant difference (e.g., *Rt plant. med* 93.50%, *left* 94.5%) Neither does there appear to be any great difference in the degree of generalization of receptor-effector relations as measured by the *segmental movements per response* (*Rt.*

plant med 6 04, *left* 5 83. See Table 3). The equalized major segmental participation (Table 5) also reveals no significant difference, and the toe representation (Table 6) is approximately the same for both limbs Likewise the character of movements, whether extension or flexion, is practically the same (Tables 7, 8, and 9).

It is therefore apparent that in homolateral reactions there is bilateral equivalence of reactivity values and, therefore, within the limits of this study, the reaction pattern of the plantar response is symmetrical

The problem of the equivalence of the contralateral patterns of behavior Possibly one of the most significant researches which could be made upon the plantar response would be the investigation of all the movements of the organism, both homolateral and contralateral, to see whether the reaction spreads as easily and as completely from the right side to the left as from the left to the right and to note whether the homologous movements have the same values regardless of the side stimulated.

Bersot (5) again, using a purely observational technique, has sought to answer part of this problem. There is need, however, for a better means of recording movements It is the writer's opinion that motion pictures should be made by means of the Yale photographic dome. The writer has experienced difficulty in bringing all of the infant within the field of view and at the same time obtaining sufficient detail. In adults, registration of homolateral leg movements in response to plantar stimulation has been accomplished through mechanical registration devices, but these are not suitable for the study of infant responses and further, they record too limited an amount of the response.

The problem of asymmetrical response patterns. With the perfection of an adequate technique it will be possible to follow any changes which may occur in the initially bilaterally symmetrical pattern. It will be possible to trace the development of asymmetry and to learn something regarding the mechanisms underlying such behavior.

The importance of such a series of studies is indicated by Steinmann (17) who reports that in certain voluntary movements, such as in learning to write, there are at first pronounced involuntary movements involving most of the body with contra- as well as homolateral representation. These decrease with age, their inhibition

being at least partially bound up with visual and postural factors

Among the common reflexes manifesting bilateral representation may be mentioned the cochlear-palpebral and visuo-palpebral reflexes Controlled or voluntary asymmetrical winking is not accomplished with equal ease on both sides. The Moro reflex is a bilaterally symmetrical response, asymmetry of the major segments being pathological The pupillary reflex is consensual.

Sometimes the bilateral representation comprises the corresponding segments but not the character of the movements. Thus in the limbs there may be flexion of one member with extension of the other The so-called "stepping movements," photographed and studied by Peiper (11), are instances of this bilateral reciprocal The arm movements of the adult in walking manifest similar bilateral features.

Conclusions

A The Reflexogenous Zone

1 During the first two weeks of post-natal existence differentiation of secondary zones within the more general reflexogenous area of the plantar response is demonstrated by differential sensitivity, segmental spread, relative degree of segmental representation, and the character of segmental movements.

2. In general, the plantar areas are most sensitive, there being a decrease in sensitivity as the proximal areas of the limb are approached.

3. The greatest "specificity" of response, in the sense of localization or limitation of movement, appears upon stimulation of the hallux.

4. The greatest "generalization" of response, in the sense of number of segments involved in active movement, is observed upon stimulation of the plantar areas

5. In general, toe areas show greater specificity than do other cutaneous areas of the lower limb.

6 Specificity is greatest when the hallux is excited and least when T5 (little toe) is stimulated.

7 The relative participation of the gross segments of the limb in the response varies according to the area of stimulation The representation of toe and foot segments is relatively less when the leg mesial surface is stimulated at the knee, while the leg and thigh

receive their greatest representation in connection with such stimulation

8. *The relative participation of the individual toes also is determined by the area which is stimulated* Thus activity is most frequent in the hallux upon stimulation of the *hallux plantar surface,* while all other toes manifest their minimum representation upon excitation of this area

9 The character of segmental movements is in part influenced by the particular cutaneous area which is stimulated The extension of the equalized *toe* segment shows highest frequency of occurrence when *tendon Achilles insertion* is stimulated, and least when the *hallux plantar surface* is excited The greatest frequency of extension of the *foot* occurs to stimulation of the *leg mesial surface,* the least to excitation of *T5 dorsum* *Leg* extension occurs most frequently upon stimulation of the *T2 dorsum.* *Thigh* extension is brought about most frequently by stimulation of *pedes dorsum*

10. The character of response of the individual toes depends upon the area of stimulation. The greatest frequency of hallux extension occurs in connection with stimulation of the *plantar lateral border* In all other toes extension has its greatest representation when the *tendon Achilles insertion* is stimulated. In all toes extension occurs least frequently to stimulation of the *hallux plantar surface.*

B. Segmental Participation in the Plantar Response

1. When the toe-segment representation is equalized, the toe and foot segments participate about equally while leg and thigh movements lag with slight frequency in the order named

2 About two-thirds of the toe-segment responses are movements of extension and one-third movements of flexion. The movements of the other limb segments are predominantly movements of flexion.

3 The high percentage of foot participation, coupled with its almost invariable flexor character, makes flexion of the foot, rather than toe and leg movements, the most invariable element of the plantar response.

4 The hallux shows greatest *individuation* of movement, and *T5* least This means that as we proceed from the hallux to *T5* there is less likelihood that the individual toes will participate in the response.

5. In general, the percentage of extension decreases as we move from the hallux to T5 and, conversely, that of flexion rises.

C Movements of Defense and the Plantar Response

1 If "withdrawal" is one of the principal characteristics of a movement of defense, then the toe movements of the plantar response are "defensive" during the first 12-14 months and again in pathological cases, but they are not "defensive" in the fetal stage, immediately after birth, and in the normal adult stage.

2. Stimulation of the dorsal surfaces of foot and toes produces flexion of the foot and extension of the toes, movements not differing appreciably in character from those released by stimulation of plantar surfaces. Yet in the first instance the members move towards and in the second away from the stimulus

3. Stimulation of the hallux plantar surface increases movements of flexion in that member, i.e., movements towards the stimulus.

4 When all aspects of the plantar response are carefully scrutinized, it becomes clear that the direction of movement of the region stimulated, with reference to the source of stimulation, presents no selective features which warrant the designation of "defense reflex."

5. Even a classification of the elements of the plantar response in terms of "approach" or "withdrawal" can have little utility if the characteristics of the response depend upon the anatomical and mechanical features as well as upon the functional peculiarities of the organism rather than upon teleological designs upon the stimulating object.

D Symmetry

1 Bilateral symmetry of the plantar median receptor areas in their receptor-effector connections is manifested by similarity in sensitivity, in gross effector-segment participation, and in the relative distribution of the type of movement (whether of flexion or of extension) of the segments of the inferior limbs

References

1 BABINSKI, J Du phénomène des orteils et de sa valeur sémiologique *La semaine med*, 1898, 18, 321

2 ——— Réflexes de défense *Rev neur*, 1915, 27, 145-155

3 ——— Réflexes de défense *Rev neur*, 1922, 38, 1049-1082

4. Bersot, H Variabilite et correlations organiques Nouvelle étude du réflexe plantaire *Schweiz Arch f Neur. u Psychiat*, 1918, 4, 277-323, 1919, 5, 305-324
5 ——— Développement réactionnel et réflexe plantaire du bebé né avant terme à celui de deux ans. *Schweiz Arch f Neur u Psychiat.*, 1920, 7, 212-239, 1921, 8, 47-74
6 Burr, C W The reflexes of early infancy. *Brit J. Child Dis.*, 1921, 18, 152-153
7 Carmichael, L Origin and prenatal growth of behavior. In *A handbook of child psychology*, 2nd ed, rev, ed by C Murchison Worcester, Mass.: Clark Univ. Press; London Oxford Univ Press, 1933 Pp 31-159
8 Collier, J An investigation upon the plantar reflex, with reference to the significance of its variations under pathological conditions, including an enquiry into the aetiology of acquired Pes Cavus. *Brain*, 1899, 22, 71-100.
9 Lantuejoul, P., & Hartmann, E Note sur le réflexe cutané-plantaire chez le jeune enfant, notamment au moment de la naissance *Rev neur*, 1923, 39, 387-399
10. Minkowski, M Ueber fruhzeitige Bewegungen, Reflexe und muskulare Reaktionen beim menschlichen Foetus, und ihre Beziehungen zum foetalen Nerve- und Muskelsystem. *Schweiz med Woch*, 1922, 52, 721-724, 751-755
11 Peiper, A Die Schreitbewegungen der Neugeborenen. *Monatsschr f Kinderhk*, 1929, 45, 444-448
12 Pratt, K C Specificity and generalization of behavior in newborn infants a critique *Psychol. Rev*, 1934, 41, 265-284
13. ——— The neonate In *A handbook of child psychology*, 2nd ed, rev, ed by C. Murchison Worcester, Mass Clark Univ Press; London. Oxford Univ. Press, 1933 Pp 163-208.
14 Pratt, K C., Nelson, A K., & Sun, K H. The behavior of the newborn infant *Ohio State Univ. Stud Contrib. Psychol.*, 1930, No 10 Pp. ix+237.
15 Rudolf, G de M Phylogenetic significance of the plantar response in man *J Neur & Psychopathol*, 1921-1922, 2, 337-352
16. Sherman, M, & Sherman, I C. Sensori-motor responses in infants *J Comp Psychol*, 1925, 5, 53-68
17 Steinmann, I Über Mitbewegungen bei Hilfsschulkindern *Zsch f. Kinderforsch*, 1931-1932, 39, 83-115.

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LA GÉNÉRALISATION ET LA SPÉCIFICITÉ DE LA RÉPONSE PLANTAIRE CHEZ LES NOUVEAU-NÉS LA ZONE RÉFLEXOGÈNE. I LA SENSITIVITÉ DIFFERENTIELLE ET LA PARTICIPATION DES SEGMENTS-EFFECTEURS SELON L'AIRE DE STIMULATION

(Résumé)

L'investigation de la zone réflexogène de la reponse plantaire chez 55 nouveau-nés âgés d'1 à 21 jours indique l'existence de zones secondaires de différentiation dans l'aire reflexogène générale Celles-ci sont montrées par la sensitivite différentielle, l'étendue segmentaire, le degré relatif de la representation segmentaire, et le caractère des mouvements segmentaires conséquents à la stimulation de diverses aires cutanées de la jambe

En général, la sensitivité décroît progressivement des surfaces plantaires proximalement le long de la jambe

La plus grande "specificite" de la réponse se montre avec la stimulation de l'hallux, la plus grande "généralisation" avec la stimulation des aires plantaires

Les segments des orteils et du pied ont la plus grande fréquence de participation à la réponse et leur représentation est environ la même si l'on tient compte du fait qu'il y a cinq orteils pour un segment du pied.

Approximativement les deux tiers des mouvements des orteils sont des mouvements d'extension La flexion est la règle dans les autres segments

L'analyse du caractere des mouvements segmentaires par rapport aux aires de stimulation et a d'autres facteurs ne montre aucuns traits sélectifs dans la réponse lesquels mériteraient le terme "réflexe de defense"

Dans les limites etudiees, la réponse plantaire, comme ordinairement evoquée, est bilateralement symmetrique à l'égard de la participation segmentaire homolatérale.

PRATT

VERBREITUNG UND SPEZIFIZITAET DES FUSSSOHLENREFLEXES BEI NEUGEBORENEN DIE REFLEXZONE I DIFFERENTIAL-EMPFINDLICHKEIT UND MOTORISCHES SEGMENT-TEILNAHME BEZUEGLICH DER ANREGUNGS-FLAECHE

(Referat)

Die Untersuchung der reflexerzeugenden Zone des Fusssohlenreflexes bei 55 Neugeborenen (1-25 Tage alt) weist auf das Bestehen der Nebenzonen von Differenziertheit innerhalb der allgemeinen reflexerzeugenden Zone Diese werden durch Differentialempfindlichkeit, Segmentausbreitung, relativen Grad der Segmentteilnahme, und Charakter der Segmentbewegungen, die auf Anregungen verschiedener Hautflachen des Beines folgen, dargelegt

Im allgemeinen nimmt die Empfindlichkeit von den Fusssohlenflachen in der Richtung des Anheftepunktes des Beines fortschreitend ab

Die grosste "Spezifizitat" des Reflexes erscheint nach Anregung der grossen Zehe, die grosste "Ausbreitung" nach Anregung der Fusssohlenflachen

Die Zehen- und Fusssohlensegmente haben die grosste Haufigkeit der Teilnahme an dem Reflex, und diese Teilnahme geht ungefahr vor sich, als wenn man sich vorstellt, dass es funf Zehen zu einem Fuss gibt.

Ungefahr zwei Drittel der Zehenbewegungen sind Ausdehnungsbewegungen Biegung ist die Regel bei den anderen Segmenten

Die Analyse der Eigenart der Segmentbewegungen im Verhaltnis zu den Anregungsflachen und zu anderen Faktoren enthullt keine auswahlende Eigenschaften im Reflex, die die Bezeichnung "Verteidigungsreflex" gestatten würden

Innerhalb der Grenzen dieser Untersuchung ist das Fussohlenreflex, wie es gewohnlich hervorgerufen wird, zweiseitig symmetrisch in bezug auf einseitige Segmentteilnahme

PRATT

VISUAL DISCRIMINATION IN THE CAT: I. THE CAPACITY OF THE CAT FOR VISUAL FIGURE DISCRIMINATION*

From the Psychological Laboratory of Brown University

KARL U SMITH

I INTRODUCTION

The experiments reported below are intended to contribute to the study of visual discrimination in vertebrates, with particular reference to the ability of the cat to discriminate visual designs At the present time the nature and development of such discrimination in animals below man is not entirely understood, and, indeed, the capacity of these animals for response to various visual configurations has not been fully ascertained. Accordingly, the aim of the present experiment has been to secure information both as to the capacity of the cat for visual figure discrimination and as to the nature of the responses involved

It seems important for clarity to separate the problem of whether the capacity for response determined by visual configurations is to be found in animals from the problem of how such responses, if found, are to be defined. The results of the present experiment are, accordingly, divided into two sections. In the present paper the question is raised as to whether or not the cat possesses the capacity for discrimination of visual figures, evidence of such discrimination being presumed when an animal responds differentially to two geometric stimuli in the absence of other sensory influences. In a succeeding paper the results of additional experiments, carried out to determine whether or not the cat's discrimination of visual figures involves responses to the form of these objects, are presented, their relation to current theories of form discrimination discussed, and conclusions stated.

II PRIOR INVESTIGATIONS OF VISUAL FIGURE DISCRIMINATION IN ANIMALS: RESULTS AND METHODS

The investigation of the capacity of various animals for visual figure discrimination has involved important problems of method

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in animal psychology and may be best discussed from that point of view. Recent investigations, as a matter of fact, have shown that results obtained are a direct function of the methods used Three variations of technique, based upon the principle of learned reactions, have been employed

1 *The Choice Method.* Under this classification reference will be made to various experiments in which an animal is required to learn to respond differentially to two or more visual stimuli which are directly associated with reward and punishment. Another significant aspect of this technique is the fact that the experimenter may form an important part of the visual situation Katz and Revesz (20) used a method of this sort in observing the reactions of the chick, which they found would respond to circles and triangles cut from green peas when the negative stimuli were covered by a thin glass plate Porter (36) used a somewhat similar method with the sparrow and cowbird, and Rouse (39) also obtained equivocal responses in the pigeon by employing this method

Sacket (40) used a variation of the choice method by having the porcupine crawl through figured holes cut in a board which was placed at the entrance into a den He found that the animal would discriminate under such conditions. McCallister and Berman (26) also have used a variation of the choice method in making observations of the responses of a cat to visual figures. Circles and squares were cut from liver sausage and placed on a board, the squares being treated with quinine in order to punish the animal for responding to them. The animal learned the discrimination in 510 trials When another experimenter took over the animal for further investigation, attempting to duplicate the method of handling previously employed in returning the cat to a restraining cage, the responses fell to 47% of this prior accuracy, thus indicating that the previous discrimination had been established on the basis of the experimenter's presence and not with reference to the liver sausages employed to stimulate the animal.

The choice method seems to have been used to particular advantage in studies of infrahuman primates. Kohts (54) studied the nature of the chimpanzee's responses to geometric forms by making it select certain ones which were accompanied by food Tellier (44, 45) has employed a similar method in the observation of the reactions of a monkey (*Macacus sinecus*) to cards bearing

visual figures, to solid geometric figures, to cards representing solid figures, and to cards bearing pictures of quadruped and biped animals, as well as pictures of animals and vegetables. Incidentally, Tellier (42, 43) has also studied the tactual responses of the same monkey to geometric figures by requiring the animal to reach into a sack containing a number of such objects. He has shown that the monkey will immediately react by touch to objects which were previously learned by visual-tactual stimulation and by visual stimulation alone

2 *The Method of Conditioned Response* This method is by far the most elaborate and infrequently used of those described in the present paper. Pavlov (35), Yerkes and Morgulis (52), and Razran and Warden (37) have reported the work of others on conditioned differential responses in the dog to such configurations as circles and ellipses, a black letter T and a hollow square of equal area, and a circle and square of equal area.

3. *The Discrimination Method* This method, as exemplified in the procedure described by Yerkes and Watson (53), is distinguished from others by the fact that the positive and negative stimuli are presented simultaneously to the animal. Furthermore, the association between the reward and punishment in this case is not so direct as in the case of the choice methods. The reward and punishment do not form part of the visual situation, while the animal's responses are relatively independent of the experimenter.

The Yerkes-Watson box has been used by Bingham (2, 3), Johnson (17, 18), and Munn (31) in observations of the reactions of the chick In these investigations the chick was found to possess the visual capacity necessary for the discrimination of two geometric figures Coburn (4) has found that the crow also discriminates simple geometric figures under the controlled conditions of the Yerkes-Watson procedure.

*In general, paradoxical results have been obtained with the Yerkes-*Watson apparatus in the study of various mammals Yerkes (50), Waugh (48), Lashley (23), and Munn (28) found no evidence of discrimination of simple geometrical figures in different rodents with the Yerkes-Watson box. Lashley did secure discrimination of horizontal and vertical lines with one animal of a large group He states (24) that since these early experiments six different groups

of animals have been tested in various types of Yerkes-Watson boxes, every one of which gave paradoxical results. Johnson (17), Williams (49), and Munn (28) have studied different carnivora by means of the original discrimination method but they found no reason to believe that the animals discriminated under such controlled conditions. Munn's experiment was intended to test the validity of Cole's experiment with the raccoon (5) in which positive results were obtained by having the animal react to visual figures presented above a screen. The Yerkes-Watson box has been used successfully, however, by Watson (47), Johnson (18), and Revesz (38) in the analysis of the monkey's responses to various visual figures.

The paradoxical results of experiments using the Yerkes-Watson technique have been interpreted by some investigators (17, 28, 48, 49) as due to defective vision in the animals observed, and by others (6, 16, 46) to defects inherent in the method itself. Among others, the following criticisms of this technique have been made. (1) the situation is too complex; (2) the electrical grill does not permit the animal to approach near enough to the stimuli for accurate vision; (3) the apparatus cannot be standardized for various animals; (4) the discrimination distance cannot be sufficiently controlled; (5) the subject is required to make no relatively isolated response to the stimuli.

Various modifications of the discrimination method have been proposed in view of eliminating one or another of the above defects. Fields (6) required rats to walk through and in under luminous stimuli and found evidence of discrimination. Munn (28) discovered that Fields's apparatus did not present visual figures of equal area to the rat and that when the figures were made equal no differential responses were observed. Fields was able, nevertheless, to demonstrate visual figure discrimination in the white rat in later experiments (7, 8), using his own apparatus, and also to compare the efficiency of visual figure discrimination in the white rat and raccoon (9).

Lashley's experiments (24) confirmed Fields's findings that white rats discriminate visual figures. He used a novel apparatus of his own invention in which animals were made to leap from a small jumping-platform against a screen containing the significant stimuli. By this method the visual acuity of albino rats for horizontal and

vertical lines was determined to be in the general vicinity of 1 degree and 26 minutes, that of pigmented animals approximately 26-52 minutes (25) The general significance of the results obtained by Lashley and of the method employed has been confirmed by certain studies by Munn (30), McKinney (27), and Fields (10), while Hamilton and Goldstein (13) have used the method in measuring the visual acuity of the pigeon, which they find to be in the neighborhood of 3 8 minutes at 31 cm distance.

An additional controlled method for the investigation of the visual responses of mammals has been invented by Munn (32) In this apparatus the animal is made to push open doors containing the positive and negative stimuli White and pigmented rats failed to learn the discrimination of a square and circle within 250 trials, although other types of discrimination were made Two dogs learned the discrimination of an upright and inverted triangle within 900 trials (19) Neet (34) established discrimination of two simple geometric figures in the monkey by using this method

Kluver (22) has devised a novel variation of the discrimination method by having monkeys drag in, by means of strings, boxes which bear the significant stimuli This method is characterized as the "pulling-in" technique, being a variation of the string-pulling experiment described by Hobhouse (14, pp 223-229) and used by Adams (1) and others with cats. Kluver studied the monkey's responses to changes involving different visual figures in connection with the "range of equivalence" for a response to two figures differing in size He also determined the visual acuity of the monkey by a variation of the same method The method used by Kluver is practically unlimited in its application for the study of discrimination in the various receptor fields of different mammals

Gellermann (11) has employed a modification of the discrimination method for the observation of the chimpanzee's and child's responses to visual figures He required his subjects to open a box upon which a positive stimulus was displayed Children learned the discrimination of a circle and a square in much less time than did chimpanzees. Munn and Stiening (32) have also described an apparatus for observing the child's responses to visual figures of various sorts

A device for the study of visual responses of higher mammals has been described by the present writer (41) The animal merely

depresses a lever below a door upon which the positive stimulus is displayed This method is applied in the present experiments to furnish needed information as to the visual capacities of the cat

III Apparatus and Procedure

The apparatus used in the present experiment can be understood by reference to Figure 1 The mechanical details of the device have already been described (41) However, further description of certain features is necessary in order to aid in clarity of exposition

The apparatus consists of a box whose front panel contains two apertures. Two doors are so mounted over these apertures that

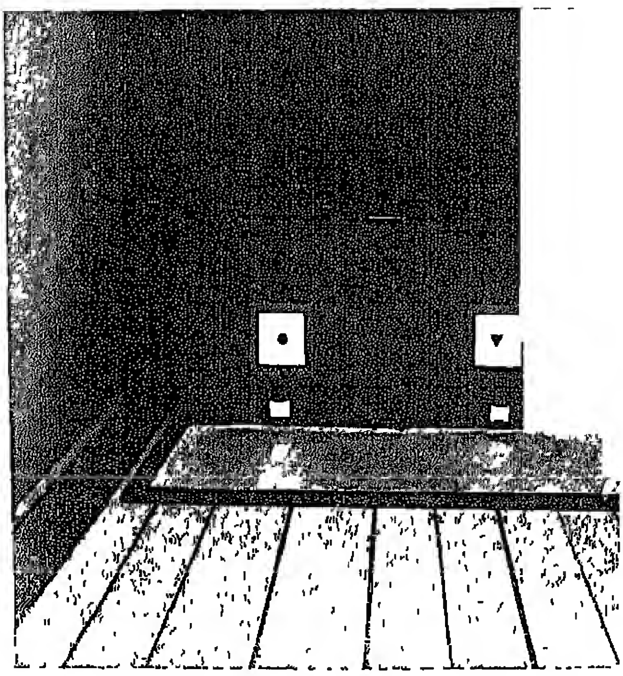

FIGURE 1
The Arrangement of the Apparatus during the Main Experiments

they swing inward by means of springs attached to their rear sides, and are fitted along their front sides with grooves into which cards bearing various visual stimuli may be inserted. The grooves open at the top, so that the stimulus cards may be quickly inserted and removed. The doors are held tightly closed by small spring latches to which are attached two brass levers that extend outward from the box and terminate in circular brass plates of a size ample to accommodate the paw of the animal. The levers are held in place by pinions at the rear of the interior of the box and emerge from two small openings directly below the larger apertures. The subject responds to the stimuli by depressing the levers, thereby opening one of the doors. A sliding master latch is mounted on the inside of the front panel and determines the door which may be opened by the subject.

Inside the box, directly below the doors, is a shelf for food containers. The shelf is so constructed that the doors may swing inward without coming into contact with the shelf or with the shallow food containers placed upon it. When either door is open the animal may thrust its head inside the apparatus and obtain food, although the remaining interior parts of the apparatus are hidden from its view by a partition at the back of the shelf. The subject may be punished by an electrical stimulus device, which was constructed from recommendations given by Howells (15) and modified to suit this apparatus.

The box is placed along one of the side walls of the experimental room and is illuminated by flood lights from the opposite wall. Two large aluminum reflectors, containing 200-watt bulbs, are employed. These lights are mounted approximately 8 ft. from the front of the discrimination apparatus, and 4 to 6 ft. from the floor, being separated from each other by at least 20 ins. The lights are so arranged as to give uniformity of brightness at the front of the discrimination box.

A restraining cage for the subject, 2 ft. by 2 ft. by 2½ ft., is placed 8 ft. in front of the discrimination apparatus. The front of the cage is fitted with grooves which contain a sliding door extending 6 ins. above the top of the box. There are no cracks in the door or between the grooves and the edge of the door through which the subject can observe movement at the front of the cage,

although ventilating cracks are arranged at the top The door is controlled by means of a string led through a series of pulleys to the outside of the experimental room

The cat is first trained to obtain food merely by depressing the levers and thus opening the doors. Training with visual stimuli is then begun In the course of the training the animal learns, when released from the restraining cage, to approach and press the levers with reference to stimuli displayed on the doors If, in any trial, the lever pressed is "correct" for that trial, the door opens and the animal thrusts its head inside and obtains food If the lever pressed is incorrect for that trial, the animal receives a slight shock from the circular brass plate, when the electrical punishment device is being used, or is otherwise merely punished by failure of the door to open. After it has obtained the food either by going to the door containing the positive stimulus or by being punished and then going to the door bearing the positive stimulus, it is returned to the restraining cage and the procedure repeated. Food is supplied in the glass containers located on the shelf behind both doors.

During experimentation the animal is alone in the room with the apparatus, observations of its behavior being made from an adjoining room through a small opening cut in the door The experimenter's observations are sometimes further supplemented by motion-picture records taken both during and after training to the visual figures.

Seven cats of unknown age and pedigree were used in the experiment. During experimentation they were segregated and kept on a strict diet of milk and commercial cat-food.[1] Each subject received ¼ of a pint of whole milk and between 1/3 and ½ of a pound of cat-food daily. The milk was given early in the morning, the cat-food after completion of the training or test trials in the evening.

The cat-food, rolled into small pellets about the diameter of a ten-cent piece, was also employed as an incentive It was found to be more satisfactory for this purpose than either fish or liver, since by dividing it into very small pieces 40 to 50 trials could be given in a single evening if necessary

After three days of the diet described above each cat was accustomed to the general experimental situation by being placed in the

[1] "Kit-E-Ration," Chappell Bros, Rockford, Ill

restraining cage and allowed to proceed to the open doors of the apparatus and obtain food placed in the glass containers Training to depress the levers was begun after 20 trials of such procedure The animal was held near one of the levers in front of a closed door and its forepaw placed on the lever, causing the lever to be depressed, and the door to be opened. The procedure was repeated with the other lever, and continued alternately between the two levers until the subject learned to proceed from the restraining cage and operate the lever itself. On the average, approximately 60 trials were required to establish the habit.

When the habit of depressing the levers was thoroughly mastered the animals were trained to respond positively to triangles and negatively to circles exhibited on cards placed as previously described on the fronts of the doors. In all of the experiments here reported, a triangle was employed as a positive or "correct" stimulus, a circle as a negative or "incorrect" stimulus The two figures of each stimulus pair were equal in area in every case and were exhibited on cards made from a smooth grade of stiff drawing paper.

Each individual animal was given a series of 20 trials a day, the experiments being carried on between 7 00 and 11 00 o'clock in the evening The subject was taken from the living-quarters, carried to the experimental room, and placed in the restraining cage The time taken by the cat to open the door bearing the triangle, as well as its behavior in approaching and depressing the levers, was recorded. An error was counted if the animal touched the lever corresponding to the negative stimulus.

When a discrimination had been made and the food eaten, the experimenter entered the room and returned the cat to the restraining cage. The top of the discrimination apparatus was then opened and fresh pellets of food placed in the glass containers behind the doors The food was handled with a pair of small tweezers, in order to make sure that no odors would attach to the stimulus cards. If an alternation in the position of the stimuli was required in the next trial, the appropriate change was made by removing the exposed cards and inserting others in their places Two different sets of cards, a positive and a negative stimulus for each door, were employed throughout the experiment When an alternation in the position of the stimuli was made, the two exposed cards were

removed and two others inserted in their places After the alternation in the stimulus cards, the master latch was thrown so as to lock the door bearing the negative stimulus, and the electrical circuit giving the punishment changed to the lever corresponding to this door During all of these operations, the experimenter stood in front of the discrimination apparatus, making as little noise as possible in opening and closing the doors of the box. He left the room always in the same direction.

The order of alternation of the stimuli between the right and left sides of the discrimination apparatus was arranged with reference to a chance procedure. A first series of alternation was calculated in which there was a possibility of 10 rights and 10 lefts This gave an arrangement for 20 trials, which was then reversed in four different ways, giving patterns of alternation similar to those suggested by Gellermann (12). After four 20-trial series the four different patterns of alternation were repeated in different order.

When an animal had learned to depress the lever corresponding to the triangle in 18 out of 20 trials, that is, maintain a level of 90% discrimination in a set of 20 trials, check experiments were introduced to ascertain whether the responses were actually determined by the visual figures or whether extraneous cues functioned in determining the selection These tests were concerned with the problem as to whether the cat possesses the capacity for the discrimination of two different visual figures.

IV. Results

The subjects were divided into two groups for investigation For a first group of three subjects, punishment was employed during the training and discontinued after discrimination had been established It was introduced around the 200th trial for all these subjects The intensity of the punishment was adjusted at the beginning to give a reading of 0 3 milliamperes on the galvanometer and was thereafter raised gradually to as high as 1 milliampere in accordance with its effect upon the behavior of the animal These limits correspond to points of imperceptibility and easy toleration for a human observer

The figures employed in these experiments were an equilateral triangle, 4 ins. on a side, and a circle, both 6 96 sq ins. in area. For the first animal white figures were exposed on black cards dur-

ing the training, while with the second and third animals black figures were exposed on white cards The difference in the front of the discrimination box for these three animals can be understood by reference to Figure 2

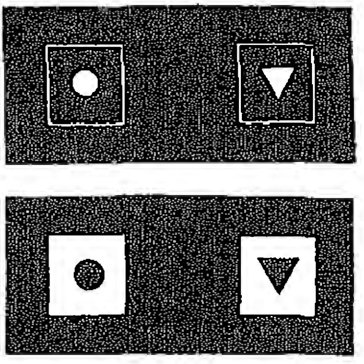

FIGURE 2

THE ORIGINAL TRAINING STIMULI

The top drawing shows the stimuli used for Subject 1, the bottom, those used for Subjects 2 and 3

For the second group of animals (subjects 4, 5, 6, and 7) no electrical punishment was employed. The stimuli used for these animals were the same as those employed for subject 1 in the first group (see Figure 2). The experimental set-up for this group of subjects was otherwise the same as that employed with the first three subjects.

The number of trials required by each subject to learn the original discrimination, together with percentage of correct responses throughout the training series, are represented in Table 1. The criterion of learning for these experiments was 90% correct choices of the triangle in a set of 40 trials. The first animal, trained to white forms on black cards, with food reward and electrical punishment, required 440 trials to reach the criterion of learning The second and third subjects were trained to respond to black forms on white cards and required 320 and 920 trials respectively to reach a level of 90% discrimination of the figures in 40 trials Evidence was obtained that the electrical punishment interfered with the learning in the case of the third subject When the punishment was discontinued at the 800th trial, correct responses to the stimuli

*Criterion of learning fulfilled

were secured within 120 trials No facts were brought out as to differences in difficulty of the two visual configurations

The second group of subjects, which were trained to black forms on white cards, required 360, 240, 480, and 400 trials respectively to fulfill the criterion of learning The learning in this situation was therefore as rapid as that in which electrical punishment was used, although no significant differences were demonstrated Learning curves for the various animals exhibit typical gradual development of efficient response

When the criterion of learning had been fulfilled by the second group of animals, additional trials were given in order to determine the stability of the responses to the figures These results also appear in Table 1 The behavior of the animals can be seen to be consistent after the criterion of learning had once been reached

Extraneous clues are believed to have been controlled Such clues could not have been obtained from the experimenter, since

TABLE 1

TRIAL SERIES AND THE PERCENTAGE OF CORRECT RESPONSES IN SETS OF 40 TRIALS DURING THE TRAINING SERIES

Trials	Subjects 1	2	3	4	5	6	7
0- 40	52.5	55.0	60.0	15.0	52.5	40.0	32.5
40- 80	35.0	52.5	32.5	35.0	32.5	30.0	37.5
80-120	30.0	52.5	45.0	47.5	42.5	40.0	57.5
120-160	47.5	50.0	25.0	80.0	72.5	57.5	60.0
160-200	57.5	45.0	40.0	72.5	80.0	47.5	77.5
200-240	57.5	47.5	55.0	75.0	*92.5	47.5	72.5
240-280	57.5	77.5	30.0	70.0	92.5	35.0	80.0
280-320	52.5	*95.0	47.5	87.5	92.5	42.5	82.5
320-360	70.0		30.0	*92.5	95.0	67.5	87.5
360-400	77.5		47.5	95.0	100.0	80.0	*90.0
400-440	*95.0		50.0	97.5	100.0	85.0	92.5
440-480			45.0	100.0	100.0	*92.5	90.0
480-520			40.0	100.0		92.5	97.5
520-560			50.0	100.0		92.5	95.0
560-600			42.5			97.5	100.0
600-640			60.0			100.0	
640-680			47.5			100.0	
680-720			47.5				
720-760			55.0				
760-800			55.0				
800-840			55.0				
840-880			67.5				
880-920			*90.0				

the animal, from the moment of release to the moment of its obtaining food, was alone in the experimental room, and itself performed the necessary manipulation of the apparatus. Clues could not have been obtained from the manner of release from the restraining cage because the cage was controlled from the outside of the room and the sliding door of the cage was always raised to the same height and so held until the animal had completed its response by inserting its head within the doors of the discrimination apparatus.

The influence of olfactory clues was controlled by utilizing two different sets of stimulus cards, a circle and a triangle for each door, and alternating the positions of the stimuli independently of other parts of the apparatus Fresh cards were exchanged for used ones at frequent intervals Odors from the food were controlled by always placing fresh pellets in the glass containers behind both doors before each response

The subjects could not respond to tactual clues and still discriminate In making a discrimination the cat touched only the levers of the apparatus, and if it touched the lever corresponding to the negative stimulus an error was recorded Differential clues from the electric shock, which might have permitted the animal to receive clues from the levers without touching them, were controlled by eliminating the shock after the criterion of learning had been fulfilled

The influence of various miscellaneous factors, which might have served as differential clues, was investigated by means of check experiments, each consisting of 20 trials, which were introduced when the subjects had met the criterion of learning. These experiments deal with: (1) the method of handling the animal when returning it to the restraining cage; (2) postural clues derived from auditory influences due to opening and closing the doors of the apparatus, (3) the order employed in the alternation series, (4) visual clues due to differences—too slight to be perceived by the experimenter—in the brightness values of the front of the discrimination box, (5) the introduction of white cards

In order to test the influences of the method of handling the animal, a new experimenter took over the subjects for a series of 20 trials with no information as to the previous manner of returning the animal to the restraining cage Postural clues were tested

by closing the doors of the discrimination apparatus in random order instead of that followed during the training series and by turning the subject around in the restraining cage after the apparatus had been arranged for the next trial The influence of the alternation order was investigated by introducing series involving single, double, triple, and quadruple alternation, instead of the arrangements previously used. The influence of varying brightness values was investigated by raising and lowering the illumination of the experimental room and by moving the lights from their usual position. White cards were introduced into the doors of the discrimination apparatus as the fifth test The results of these separate experiments are summarized in Table 2, which shows the

TABLE 2

PERCENTAGE OF CORRECT CHOICES IN TESTS FOR EXTRANEOUS CLUES

Factor tested	Subjects 1	2	3	4	5	6	7
1 New experimenter	90	95	85	100	95	95	95
2 Postural clues	100	95	90	100	100	100	100
3 Alternation series	90	85	90	100	100	100	100
4. Changed brightness	95	85	90	100	100	100	100
5 White cards	40	50	40	45	40	40	45
Trial inclusive of tests	540	1020	420	460	340	580	500

percentage of correct responses for each subject during the separate tests, as well as the point in the trial series when the tests were made. The character of the tests is indicated in each case.

It is evident from the table that the subjects were not significantly affected by the variations intended to determine the influences of extraneous clues. In isolated instances only did the number of correct responses drop below 90%, and it was never below 85% Further evidence indicating that the subjects received no differential extraneous clues from the experimental situation was furnished by the introduction of blank cards. The fact that the failure to discriminate was complete in this test indicated that no extraneous clues functioned in determining the discrimination and that the visual figures were required for a differential response.

As a result of these tests, the positive evidence on visual figure discrimination in the cat was considered to be complete.

V Summary and Conclusions

Seven cats were trained and tested under controlled conditions in the discrimination of geometric figures in an attempt to answer the question as to whether these animals could respond to two different visual configurations. Of seven subjects used all learned the discrimination of a configuration consisting of a triangle and a circle of equal area Two animals learned the discrimination when black figures were exposed on white cards, five discriminated when white figures were exposed on black cards. In both cases the cards were exhibited against the black panel of the front of the discrimination box

A median number of 400 trials was necessary before the seven subjects fulfilled a learning criterion of 90% discrimination of the figures in 40 trials The required responses were obtained both with and without electrical punishment as a condition of learning Three subjects were trained with electrical punishment, four without. One subject of the former group showed no progress in learning so long as the punishment for incorrect responses was used, but when it was discontinued the criterion of learning was fulfilled in 120 trials.

The apparatus employed controlled the common sources of error in experiments dealing with visual discrimination. The effects of extraneous clues in the method of handling the animal, the order of alternation, the manner of opening and closing the doors of the discrimination apparatus, and the brightness values of the front of the discrimination apparatus were found to be negligible in a series of check experiments. Also, when blank cards were introduced, the discriminative responses failed to appear The discrimination was therefore taken to be a function of the stimuli employed in the training

In general, the data here secured agree with the results of other controlled experiments on the visual capacity of infraprimate animals Lashley (25) has shown that a circle and triangle offer a difficult discrimination for pigmented rats when the jumping-method is used Fields (10) has found by Lashley's method that the average accuracy of white rats in discriminating a circle and triangle

was 86.4% at the 650th trial The results on visual figure discrimination in the cat also compare favorably with those obtained by Karn and Munn (19) for the dog They found that two dogs would discriminate consistently an upright and inverted triangle within 900 trials These comparisons are cited to attest the value of the cat as a subject for psychological investigation as well as the present method of exploration devised for such study.

Munn (32), in discussing the aspects of method which apparently account for the conflicting results on discrimination of visual figures by different animals secured by the Yerkes-Watson technique, as compared to the results obtained with his own and Lashley's method, discounts the significance of delayed feeding, while attributing the difference in results to the different methods of punishment employed Although the results obtained here do not permit the factor of proximity between stimuli and reward to be overlooked as an important influence in determining discrimination, the conclusion of Munn as to the significance of differences in punishment is emphasized. By the present method the animal was shocked simultaneously or shortly after the response to the stimuli had been made, and under these conditions the punishment definitely interfered with the progress of learning in one animal and did not facilitate that of others. An additional factor, which has not been taken into account by Munn, concerns the relative importance of requiring an isolated response on the part of the animal No such response is required in any of the maze-type discrimination boxes, whereas in the present experiments, as well as in those reported by Lashley and Munn, the animal is required to pause to make a definite response in the direction of the positive or negative stimulus.

The investigation of certain aspects of the cat's visual responses to the figures employed in these experiments has already been carried out The results of this study and conclusions concerning their significance are presented in a subsequent paper dealing with the problem of form discrimination in the cat.

References

1. Adams, D K. Studies of adaptive behavior of cats *Comp Psychol Monog*, 1929, **6**, 109-122.

2 Bingham, H C. Size and form perception in Gallus Domesticus *J Anim. Behav.*, 1913, **3**, 65-113

3 ——— Visual perception in the chick *Behav Monog*, 1922, 4, Pp vi+104

4 COBURN, C. A The behavior of the crow *J Anim Behav*, 1914, 4, 185-201

5 COLE, L. W Observations of the senses and instincts of raccoons *J Anim Behav*, 1912, 2, 299-309

6 FIELDS, P E Discrimination in the white rat *J. Comp Psychol*, 1928, 8, 143-158

7 ——— The white rat's use of visual stimuli in the discrimination of geometric figures *J Comp Psychol*, 1929, 9, 107-122

8. ——— Contributions to visual figure discrimination in the white rat *J Comp Psychol*, 1931, 11, 349-367.

9 ——— A comparison of white rats and raccoons with respect to their visual discrimination of certain geometric figures *Psychol Bull.*, 1932, 29, 61

10. ———. Studies in concept formation *Comp Psychol Monog*, 1932, 9 Pp 70

11. GELLERMANN, L W Form discrimination in chimpanzees and two-year-old children I Discrimination of form per se II Form versus background *J Genet Psychol*, 1933, 42, 1-50

12 ———. Chance orders of alternating stimuli in visual discrimination *J Genet Psychol*, 1933, 42, 206-208.

13 HAMILTON, W. F, & GOLDSTEIN, J L Visual acuity and accommodation in the pigeon *J. Comp Psychol*, 1933, 15, 193-199.

14 HOBHOUSE, L F Mind in evolution London Macmillan, 1915 Pp 415

15. HOWELLS, T H An electrical stimulus apparatus *Amer J Psychol*, 1931, 43, 126-127

16. JOHNSON, H M Hunter on the question of form perception in animals *J. Anim Behav.*, 1914, 4, 134-135

17 ———. Visual pattern discrimination in vertebrates. II Comparative visual acuity of the monkey, the dog, and the chick *J Anim. Behav*, 1914, 4, 340-361

18 ——— Visual pattern discrimination in vertebrates· IV Effective differences of visible striae for the monkey and the chick *J Anim Behav*, 1916, 6, 189-204

19 KARN, H W, & MUNN, N L. Visual pattern discrimination in the dog. *J Genet Psychol*, 1932, 11, 363-375

20 KATZ, D, & REVESZ, G Experimentell-psychologische Untersuchungen mit Huhnern *Zsch f Psychol*, 1908, 50, 59-116.

21 KINNAMAN, A J Mental life of two Macacus Rhesus monkeys in captivity *Amer. J Psychol.*, 1902, 13, 98-173

22 KLÜVER, H. Behavior mechanisms in monkeys Chicago Univ. Chicago Press, 1933 Pp vii+387

23 LASHLEY, K S Visual pattern discrimination in the albino rat *J Anim Behav*, 1912, 2, 310-331

24. ———. The mechanism of vision I A method for rapid analysis of pattern vision *J Genet Psychol*, 1930, 37, 453-460.

25. ——— The mechanism of vision III The comparative visual acuity of pigmented and albino rats *J Genet Psychol*, 1930, 37, 481-484.

26 McCallister, W G, & Berman, H. D Visual form discrimination in the domestic cat *J. Comp Psychol.*, 1931, 7, 207-243

27 McKinney, F. Identical sensory elements versus functional equivalents in visual transfer reactions *J. Genet Psychol*, 1932, 41, 483-489

28 Munn, N L Concerning visual figure discrimination in the white rat. *J Genet. Psychol*, 1930, 36, 291-302

29. ——— Pattern and brightness discrimination in raccoons. *J Genet Psychol.*, 1930, 37, 3-34.

30 ———. A note concerning Lashley's method for studying vision in the rat *J. Genet. Psychol*, 1930, 37, 552-553.

31. ——— The relative efficiency of form and background in the chick's discrimination of visual patterns *J. Comp Psychol*, 1931, 12, 41-75.

32. ——— An apparatus for testing visual discrimination in animals. *J. Genet Psychol*, 1931, 39, 342-357

33. Munn, N L., & Stiening, B The relative efficiency of form and background in the child's discrimination of visual patterns *J Genet Psychol*, 1931, 39, 73-90

34 Neet, C C Visual pattern discrimination in the Macacus Rhesus monkey *J Genet Psychol*, 1933, 43, 140-163

35 Pavlov, I P Conditioned reflexes (Trans by G V. Anrep) London: Oxford Univ Press, 1927. Pp xvi+430

36 Porter, J P *A further study of the English sparrow and other birds* *Amer J Psychol*, 1906, 17, 248-271

37 Razran, H. S, & Warden, C J. *Sensory capacity of dogs as measured by conditioned responses* (Russian Schools) *Psychol Bull*, 1929, 26, 202-222

38 Revesz, G Experimental study of abstraction in monkeys. *J Comp. Psychol.*, 1925, 5, 293-343

39 Rouse, J E. The mental life of the domestic pigeon. *Harvard Psychol Stud.*, 1906, 17, 248-271.

40. Sackett, L. W. The Canada porcupine: a study of the learning process. *Behav Monog*, 1913, 2, 43-44

41. Smith, K. U An apparatus for the study of vision in the higher vertebrates *J Genet Psychol*, 1933, 43, 462-466

42 Tellier, M Reconnaissance par le toucher d'objets connus par la vue, chez le Macaque *Bull Soc. roy des sci de Liége*, 1932, 5, 114-117

43. ——— Le sens du toucher et la généralisation, le rélatif et l'absolu, chez le Macaque *Bull Soc roy. des sci de Liége*, 1932, 7-10, 192-196

44 ——— L'intelligence des singes inférieurs la vision des formes et la généralisation *Mem Soc roy des sci. de Liége*, 1933, 19 Pp ii+76

45 ——— Le choix d'après modèle, chez le Macaque *Bull Soc roy. des sci de Liége,* 1933, 2, 41-45

46 VINCENT, S B The mammalian eye *J Anim Behav,* 1912, 2, 249-255

47 WATSON, J B Behavior an introduction to comparative psychology New York: Holt, 1929 Pp xii+439

48 WAUGH, K. T. The role of vision in the mental life of the mouse *J Comp Neur. & Psychol,* 1912, 20, 549-599

49 WILLIAMS, J Experiments in form perception and learning in the dog. *Comp Psychol Monog.,* 1926, 4 Pp 70

50 YERKES, R M The dancing mouse New York Macmillan, 1907 Pp xxii+290

51 ——— The discrimination method *J Anim Behav,* 1912, 2, 142-144

52 YERKES, R M, & MORGULIS, S. The method of Pavlov in animal psychology *Psychol Bull,* 1909, 1, 257-273

53 YERKES, R. M & WATSON, J B Method of studying vision in animals *J Anim Behav.,* 1911, 1, No 2 Pp iv+90

54 YERKES, R M, & PETRUNKEVITCH, A Studies of chimpanzee vision by Ladygin-Kohts *J Comp Psychol,* 1925, 5, 99-108

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LA DISCRIMINATION VISUELLE CHEZ LE CHAT I LA CAPACITÉ DU CHAT POUR LA DISCRIMINATION VISUELLE DES FIGURES

(Résumé)

Dans un appareil construit pour permettre l'observation contrôlée des réponses du chat aux stimuli visuels on a entraîne les animaux à répondre positivement à un triangle et négativement à un cercle au moyen de déprimer un petit levier immédiatement sous une porte sur laquelle on a montré le stimulus positif De la nourriture placee sur une planchette derrière la porte a été obtenue quand les réponses ont etc correctes D'entre sept sujets employés tous ont appris à discriminer entre un triangle et un cercle de même aire On s'est servi de figures noires sur des cartes blanches dans l'entraînement de deux de ces animaux et de figures blanches exposées sur des cartes noires dans l'entraînement de cinq Les expériences de contrôle ont montré que la méthode de manier l'animal et les stimuli extérieurs possibles n'ont pas influe sur la discrimination Comme contrôle supplémentaire, on a constaté que les réponses discriminatives ne se sont pas montrées du tout quand on a présenté des cartes complètement blanches au lieu des figures

Les résultats définiment vérifiés obtenus dans cette expérience sont comparés à ceux obtenus sur la discrimination visuelle des figures chez d'autres animaux On est en train de faire une analyse expérimentale des facteurs signifiants trouvés dans la réponse du chat aux cercles, aux triangles, et à de semblables configurations visuelles

SMITH

OPTISCHE UNTERSCHEIDUNG BEI DER KATZE I DIE FAEHIGKEIT DER KATZE ZUR OPTISCHEN FIGURENUNTERSCHEIDUNG

(Referat)

In einem Apparat, der zur kontrollierten Beobachtung der Verhaltungsweisen der Katze bei optischen Reizen erbaut wurde, wurden Tiere dressiert, positiv auf ein Dreieck und negativ auf einen Kreis durch Niederdruckung eines kleinen Hebels direkt unter einer Tur, an der der positive Reiz gezeigt wurde, zu reagieren Die Nahrung auf einem Regal hinter der Tur wurde von den Tieren erreicht, wenn die Antworten richtig waren. Von sieben Tieren lernten alle ein Dreieck von einem Kreis von demselben Flacheninhalt unterscheiden Zwei von diesen Tieren wurden mit schwarzen Figuren auf weissen Karten und funf mit weissen Figuren auf schwarzen Karten dressiert Kontrollexperimente zeigten, dass die Behandlung des Tieres und mogliche aussere Reize keinen Einfluss auf die Unterscheidung hatten Durch eine weitere Kontrolle wurde festgestellt, dass, wenn blanke Karten statt Figuren vorgelegt wurden, die Unterscheidung ausblieb

Die nachgepruften Ergebnisse dieses Experiments werden mit denen von optischer Figurenunterscheidung bei anderen Tieren verglichen Eine experimentelle Analyse der bedeutenden Faktoren, die in den Antworten der Katze auf Kreise, Dreiecke, und ahnliche optische Gestalten vorkommen, wird dann gemacht

SMITH

THE PERCEPTION OF CHILDREN A GENETIC STUDY EMPLOYING THE CRITICAL CHOICE DELAYED REACTION*[1]

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I INTRODUCTION

The question, what is the stimulus, is crucial to the prediction of responses ranging all the way from the conditioned reflex to insight. Watson (14) found that a child's conditioned fear of a rabbit spread to whiskers, muffs, and many other objects, but the conditioning of eating responses to the rabbit removed all these fears (5). It is certainly difficult to define the stimulus that was being conditioned here In psychophysics the stimuli are already put into a fairly serviceable form by physics. In most other fields the definition of the stimuli is almost exclusively a psychological problem. Whether or not an organism will respond to two social situations as similar or dissimilar is a query whose answer will not be found in the average engineering handbook It has long been known that melodies can be recognized though transposed, that objects learned at one distance or angle are often recognized at another though the individual receptors and even the spatial pattern of receptors stimulated may be different But once we admit, as we must in the face of these and a host of

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other facts, that the stimulus is not completely simple, we are in a dilemma. The stimulus-response formula becomes inadequate to the extent that the stimulus remains inexactly defined. The state of affairs is made worse if we say that the whole situation is the stimulus, because whole situations never exactly repeat themselves. The ambiguity of the effective stimulus becomes especially troublesome in the realms of transfer of training and insight. The crucial point about experiments in these realms is that the animal is supposed to be responding to a new or different situation and a precise definition of the effective stimuli in two contrasted situations is necessary if we are to know in what respects, if any, a psychological difference actually exists.

Since the problem of studying the factors which govern the narrowing of the infinity of possible stimuli groupings down to certain functional units is complex, it appears highly advisable to use the advantages of a genetic approach covering as much as possible of the developmental range. The undeveloped organism in some respects is simpler than the fully developed one so that the operation of one function can be observed in relative isolation from other functions which have not yet appeared. Many of the functions are more unified at first so that certain relationships can be understood better by watching the early stages of differentiation On the other hand, some of the advanced levels of development have their functions well specialized so that different aspects of them stand out more clearly and may the more easily be observed Thus each level has something to contribute toward the end of stimulus definition. Furthermore, a study of developmental sequences can be made and is desirable because when different functions always appear in the same sequence some mechanism in common is indicated

In addition to the light thrown upon general theoretical problems, there is a certain practical reason for making a comparative study of all developmental levels Rats seem equal to humans in maze learning (3), but are obviously inferior at calculus Infants give a more violent negative response to lemonade than to quinine, while the reverse is true for adults (10). These and other facts seem to indicate that the changes taking place during development are not only quantitative but also qualitative From the point of view of the selection of the most efficient time and means for any given type of training, a knowledge of these qualitative changes is necessary

II The Problem

The purposes of this study were (1) to devise a technique for isolating qualitative differences in perception of children which is applicable over a wide age range, especially to very young children, and (2) to test this technique by making an exploratory, genetic study of some of the more fundamental aspects of perception.

Sample of Previous Studies Usnadze (13) studied the grouping of objects by children three to eight years of age. The objects consisted of figures cut out of cardboard and differing in color, size, form, markings, and position. Younger children grouped the figures according to the spatial relations of subject and material. Older children grouped the material according to its characteristics: color, form, size, markings, this seeming to be the order of ease.

Tobie (12) required 1000 preschool children to choose from an array of different forms, each of which appeared in several colors, those which were like the form of a specific color. Up to 3 yrs. 8 mos, the relative obtrusiveness of the color or form determined which was selected From 3 yrs 8 mos. to 5 yrs 1 mo, the children tended to respond to color. With 5 yrs 2 mos, the ability to respond selectively to either form or color began to appear. The chief drawback to the technique used in this study is that the younger children do not understand the directions and exhibit so much random behavior that it is difficult to interpret their responses.

Rickel (11) gave children sweet chocolate on a medium gray plate and very bitter chocolate on a dark gray plate. The 2-4-year-old children took 60-75 trials to learn to choose the chocolate on the medium gray plate. The 4-6-year-olds took 20-30 trials When medium and light grey plates were substituted, 42 out of the 60 children 2-6 years old chose the light gray plate That is, 70% (S.E $\pm 6\%$)[2] of the children chose on a relative basis.

Luria (9) gave children candy for picking up any cube out of a square of 16 cubes and a 17th placed outside. The 1½-2-year-old children picked at random The 2½-3-year-old children invariably chose the outside cubes Told to count the cubes in a cross made up of 11 cubes, the 2-3-year-olds counted at random, the 4-5-year-olds counted one array and then the other, but 62 5% of them counted

[2]The standard error of the percentage This was calculated from Edgerton's table (2)

the middle cube twice as opposed to 6.2% of the 8-9-year-olds Children 4-6 years of age were required to divide a number of cubes among themselves Three stages of behavior were noted. (*a*) no effort at planful or equal distribution, (*b*) figures made up of the cubes and each child given a figure, (*c*) shares equalized by arranging in columns and seeing that columns were equal

All of these experiments suggest that a complicated series of qualitative changes is taking place in the perceptive processes of the child. To study these changes, a technique is needed which can be applied without too much modification to a large number of very different situations so that the results from them can more easily be compared In order to be adapted to very young children, such a technique should not require verbal instruction or motivation.

Technique. The technique thought most likely to meet the above requirements was the direct method of delayed reaction Hertz (4) has used this method to study the effect of configuration upon the behavior of birds. A seed was placed under one of several similar flower pots while the bird was watching from a limb It was found that the birds could pick correctly only a pot which stood apart in the grouping. Leeper (8) has secured direct delayed reactions from a 13-months-old child. He found that it was able to make a discrimination between two objects after a period of 75″ in spite of loss of orientation. We thought that an analysis of the types of configurations to which children of different ages could respond might yield a better understanding of the laws of perceptual development Light pasteboard boxes 2¼″ by 2⅛″ and ¾″ deep, coated with red[a] paper were used, and the situation was set up as a game. A toy was hidden under one of the boxes, a screen momentarily interposed between the boxes and the child, and the child directed to find the toy The motivation proved to be excellent The chief difficulty with this power-of-discrimination type of experiment was found to be that, in order to determine the stage of complexity at which the children were no longer able to respond, it was necessary to repeat the situation to such an extent that the factor of learning became involved

At the same time experiments were being conducted with a slightly

[a]Munsell colored papers, maximum red, yellow, green, purple, and blue, numbers 4, 20, 12, 36, and 28 respectively, were used in these experiments

different type of approach which was found to be a better tool, at least for preliminary work. A delayed-reaction situation was set up in which two or more cues could be used to identify the correct box. After this original situation had been solved correctly, it was presented again But this time the set-up was altered during the period of delay so that the cues, instead of reinforcing each other, were in conflict This resembles the "critical-trial" procedure in the previous reference to Riekel (11), save that the much easier direct delayed reaction replaces the 20 to 75 learning trials.

Subjects. The subjects were 98 children, ranging in age from 11.5 to 162 months. Mrs Anderson's Nursery School in Palo Alto, California, contributed 17; the Institute of Child Welfare at the University of California, Berkeley, 36, the Berkeley Day Nursery, 19; and the New Haven County Home, West Haven, Connecticut, 26 The social status of the first two of these groups was considerably above average, that of the last two was below average. The results were tabulated, separately at first for the four groups, but, since the main trends of this study were found to hold in each, they have been combined in this paper.

General Procedure A number of different experiments were tried out on successive days in the Palo Alto group Those which seemed most promising were selected and combined into two 15-minute series. The first series was composed of the following experiments 1A 2, 5B, and 4. The second series consisted of 1B 3, 5C, and 6[4] The plan was to rank the subjects according to age and give the even subjects the first series and the odd subjects the second series; then, to give the odd subjects the first series and the even subjects the second. The following deviations were made from this plan: Irregularities in the schedule caused about twice too many subjects to be given the first series first; the transient nature of the group at the Berkeley Day Nursery made it advisable there to administer the two series at a single sitting, the trend of results indicated that it was unnecessary to administer Experiments 2 and 6 to all of the subjects, and only Experiment 1A was given to the children at the New Haven County Home The differences in procedure are between the various groups. Since the major trends of this study hold within each of these groups, it can be

[4]See description of experiments

concluded that they are not artifacts of the differences in procedure

III. Experiments and Results

Experiment 1 Position and color enter into almost every experimental set-up The logical place to begin seemed to be with these in their simplest possible configuration. The purpose of this experiment was to determine for a discrimination between two boxes (1) the effect of age in a conflict among the cues. position relative to the other box, position relative to the subject, and color, and (2) the effect of the distance between the two boxes in the same conflict

Two boxes, 2¼" by 2⅛" and ¾" deep, one red and the other yellow, were placed before the subject on the edge of a white, paper-covered table 8 feet long. A table of such length was used in order that the table-ends might be removed from the situation. The white paper was used to give a homogeneous surface to the table. In set-up A the boxes were placed so that their centers were in line with the tips of the subject's shoulders. In set-up B the boxes were twice that distance apart It was thought that this dimension of the subject, the dimension which enters most into the reaching situation, would be more significant than an absolute distance.

The procedure was to seat the subject in a chair opposite the experimenter and say, "Do you like to play games? See the dog. It's a nice dog, isn't it? See the boxes. Now I'm going to hide the dog under a box Look!" At this point the toy was hidden Then, a white pasteboard screen, 36" by 20", was interposed between the boxes and the child, and held there for 10 seconds. "Now see if you can find the dog. Fine!" Then the toy was taken from the subject and hidden under the same box. "Now see if you can find the dog again." This procedure seemed to produce very good motivation with almost all of the subjects. With a few, interest had to be kept at a maximum by using other toys—boats, crickets, dolls, rabbits, etc. The children of less than 18 months presented some special problems, since it was hard to get objects which were more attractive to them than the boxes themselves Graham crackers were used At other times, objects such as tape measures, radiator keys, and spools, in which the children seemed to be showing a temporary interest, were more successful

The youngest were encouraged to find the objects by gesture and example.

The finding procedure was repeated until the subject got the idea as evidenced by two correct choices in succession These were usually the first two trials. Then the critical trials were made In these the situation was altered behind the screen, and a toy identical with the one hidden was put under the hitherto empty box. There were three critical trials in this experiment. The toy was hidden in the same manner before each trial. In Figure 1 let the

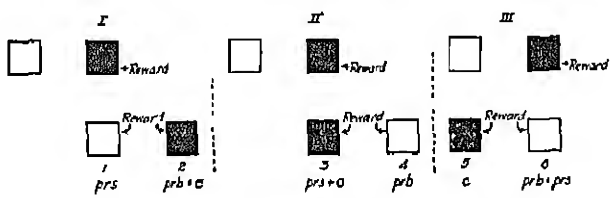

FIGURE 1

THE SHIFTS MADE IN THE THREE CRITICAL TRIALS OF EXPERIMENT 1

top line of squares represent the situations before the screen was interposed and the lower line represent the critical choice positions Let us designate each of the latter by a number for purposes of reference And below each number let us symbolize the dominance of the cue that each choice indicated: *c* for color, *prs* for position relative to the subject, and *prb* for position relative to the other box. If the child uses the same cue consistently throughout the series of critical choices and that cue is color, he should choose 2, 3, and 5. If the relative position of the boxes to each other is his cue, he should choose 2, 4, and 6 If position relative to himself is his cue, he should choose 1, 3, and 6. And if the box having two cues is always selected, he should choose 2, 3, and 6 There are four other unclassified possibilities 1, 3, 5—1, 4, 6—2, 4, 5—and 1, 4, 5

The data of this experiment are presented graphically in Figure 2 The results were as follows.

1 Only 2% (S E $\pm$1 5%) of the critical choices of the children 11.5-60 months of age fell into one of the four unclassified patterns of response Since there were eight possible patterns of response, one-half of the total number of random choices would be expected to fall into one of these four Thus the most probable percentage

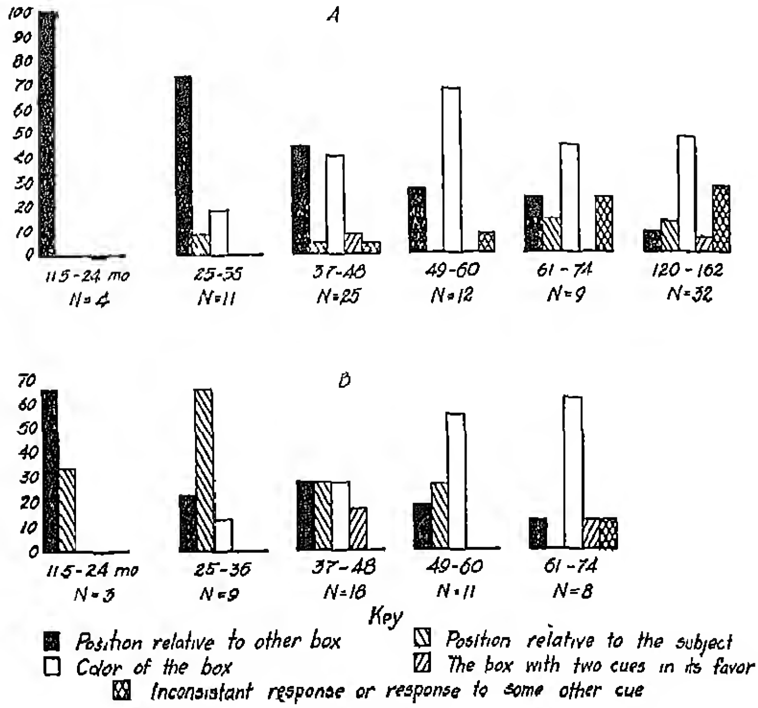

FIGURE 2

THE PERCENTAGE OF RESPONSES TO EACH CUE FOR SUCCESSIVE AGE INTERVALS UNDER THE TWO CONDITIONS OF EXPERIMENT 1

A—with the distance between the centers of the two boxes equal to the width of the subject's shoulders

B—with this distance doubled

of cases in which these children did not choose consistently on the basis of one of the four specified cues is 4% (S.E.±3%).

2. The percentage of choices in the unclassified category increased consistently with age There were 22% (S E.±6%) of the critical choices of the children 61-172 months of age which fell into some one of these four patterns of response

3. Only 6% (S.E.±2%) of the critical choices of all of the children fell into the pattern indicating that the box having two cues in its favor was always selected.

4. Changing the distance between the center of the two boxes

from the width of the child's shoulders to twice that width did not have a significant effect on the percentage of choices on the basis of color, two cues, or chance. This change caused 46% (S.E ±11%) of the position choices to be shifted from the basis of position relative to the other box (*prb*) to the basis of position relative to the subject (*prs*).

5 Position, relative to the subject or to the other box according to the set-up, was almost completely dominant over color for children under the age of three.[5] This dominance decreased markedly and consistently with age.[6]

6. The frequency with which color was used as a dominant cue increased rapidly between the ages of three and five [7]

7. The distribution of the responses of the older children among more categories and the consistent increase with age in the number of responses in the last, or unclassified, category indicates that the older children were responding to a greater variety of cues.

Experiment 2. In most situations configuration and position are combined in rather complex manners The purpose of this experiment was to observe the effect of age in a conflict for dominance between two cues, namely, a certain simple configuration and a combination of position relative to the subject and position relative to the other object. Four red boxes were placed side by side to form a square and a fifth box was placed 6 ins. to one side of the square. The procedure was the same as in the previous experiments A toy was hidden under the fifth box and found by the child twice in succession In the critical trials the fifth box was shifted to the

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[5]This agrees with the previously quoted results of Usnadze (13) on the grouping of objects by children Yerkes and Yerkes (16) find chimpanzees react much more readily to position than to color

[6]The data in Figure 2 tend to suggest that position relative to the other box is a more primitive cue than is position relative to the subject It was the oldest of the children in the age range 11 5-24 mos who contributed the one response in this class interval on the latter basis (Figure 2B) The youngest, 11.5 mos, chose on the basis of position relative to the other box even when the boxes were so far apart that she had to lean and stretch to her utmost to reach the "correct" one She was allowed to maintain her orientation in these trials Subsequently she demonstrated that she was able to react successfully the first time to either side after a 10-second period of being swung around and shaken above her mother's head

[7]A similar increase in the dominance of color over form has been found by Tobie (12) and by Brian and Goodenough (1) Our results suggest that the dominance of color may fall off somewhat after the age of five This would parallel the results of the latter investigators on color *vs.* form.

other side of the square and similar toys were under all of the boxes. The results are summarized in Table 1 It can be seen that in this

TABLE 1
RESPONSES IN EXPERIMENT 2
(19 cases)*

Subject age in mos	Configuration dominant cue	Position dominant cue
11 5-24	0	4
25-36	2	0
37-48	6	0
49-60	3	0
61-74	4	0

*The probability that the array in this table was produced by chance rather than by some change related to age is lower than 002

situation position is the more primitive cue, but that the configuration becomes dominant over position at an earlier age than does color (Figure 1A).

Experiment 3 The purpose of this experiment was to observe the function of age in a conflict for dominance between two cues—a certain configuration and a certain color The set-up was similar to that of the preceding experiment except that the fifth box was yellow. The toy was hidden and found under this box in the usual manner In the critical trial this box was exchanged with the red box from the corner of the square adjacent to it and the child

TABLE 2
RESPONSES IN EXPERIMENT 3
(56 cases)

Subject age in mos.	Configuration dominant cue	Position dominant cue
11 5-24	1	0
25-36	5	5
37-48	14	9
49-60	6	4
61-74	1	6
117-132	3	2

The results are summarized in Table 2 None of the children chose any of the three boxes that had no cues in their favor There was a 14% (S.E.±14%) increase in the percentage of choices on the basis of color from 49-132 months over those from 21-48 months.

It would appear that the color cue and this specific configuration run a more parallel course of development than do color and position (Figure 2A). More cases would be necessary to draw definite conclusions An examination of the behavior of the children of 25-36 months in this experiment compared to their behavior in the previous two experiments brings out some facts which are rather suggestive. In Experiment 1 relative and absolute position combined are stronger than color for 82% (S E ±9%) of these children In Experiment 2 configuration is stronger than relative and absolute position combined for 100% of these children But in Experiment 3 configuration plus relative and absolute position combined are stronger than color for only 50% (S E ±16%) of the same children These results suggest that four boxes of the same color and one of a different color is a stronger or more primitive cue than the same difference of color between two boxes

Experiment 4. The purpose of this experiment was to observe the use of the cue, "box-of-a-different-color," as a function of age. Three red boxes and a yellow one were placed together to form a square on a piece of white cardboard placed over a small disk that could be rotated by hand. The toy was hidden under the yellow box, the disk was given a slow spin, and while it was still revolving the screen was interposed After a 10-second delay, the screen was withdrawn and the boxes brought to rest with the box covering the toy in a different position from that in which the toy had been hidden This procedure was repeated till the child made three successive correct choices.[8] In the critical trial three green boxes and a purple box with toys under each box were substituted for the three red boxes and the one yellow box A choice of the purple box was recorded in the "use-box-of-different-color" column, a choice of one of the green boxes was recorded in the "failure-to-use-box-of-different-color" column. If the choices were entirely random, one-fourth would be expected to fall into the former and three-fourths into the latter.[9] The results are summarized in Table 3. There

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[8]Position habits were hard to break up with the very young children, confirming the results of Experiment 1 Placing the toy on top of the yellow box during the first rotation of the disk or allowing the child to make his first choice after the boxes had been slowly rotated in front of the screen seemed to be practical aids in teaching the child the initial delayed reaction.

[9]In the light of the results of the previous experiments, it is probable that, if the choices in the latter column were analyzed, they would be found not to be random, but to be consistent on some basis other than the cue "different"

TABLE 3
RESPONSES IN EXPERIMENT 4
(35 cases)

Subject age in mos	Use box-different-color as cue	Box-different-color not used as cue
11.5-24	2	0
25-36	6	3
37-48	7	4
49-60	8	0
61-74	3	1
117-132	1	0

is a definite tendency of even the younger children to use the cue "box-of-a-different-color."[10] It was found that 68% (S E ±10%) of the children 11-48 months of age chose the purple box as opposed to the 25% (S.E. ±10%) who would be expected to by chance. This is a difference of 43% (S E ±14%) There is a suggestion of a tendency for the older children to use this cue more often than the younger as 92% (S E ±8%) of the children of 49-132 months chose the purple box This is 24% (S E ±13%) greater than the percentage for the group of 11-48 months

Experiment 5 The preceding experiment shows that a configurational difference of color, independent of the specific colors involved, may be used as a cue by very young children. The Gestalt theory of development, if we understand it correctly, would predict this result by the following line of reasoning. Development is a differentiation or individuation of the whole into its parts.[11] Configurational relations are functions of the whole and absolute relations, so-called sensations are functions of the parts Therefore configurational relations are more primitive than absolute relations [12] Since the-different-color is a configurational relation, it will be a more primitive cue than the-specific-color which is an absolute relation.

[10]Kluver (8) finds that monkeys have a tendency to pull in the different object first In order to get some idea of whether the behavior of our children was determined by this general habit or by a transfer from the immediately preceding delayed reaction, we reversed our experiment on four subjects who had used difference in color as a cue Toys were hidden under the three red boxes but none under the yellow In each of the critical trials the three purple boxes were picked up before the green one

[11]See Wheeler (15) page 14, line 30, and page 529, line 42, to page 530, line 27

[12]See Koffka (7) page 141, line 25, to page 142, line 12

It can be seen that the Gestalt theory of development predicts that very young children will respond to a configurational difference in color and that a response to this cue will be a more primitive type of reaction than a response to specific colors. It was the purpose of the present experiment to test the latter part of this deduction by studying the function of age in a conflict for dominance between the cues box-of-a-specific-color and box-of-the-different-color. According to the Gestalt theory the dominance of the latter should be relatively greater among the younger children.

Three procedures were used. 5A—The child was taught, as in the preceding experiment, to find the toy under the yellow box in a square made up of three red boxes and one yellow box. In the critical trial the child was confronted with a square made up of three yellow boxes and one red box. 5B—A blue and a green box were placed 1½ inches apart in the center of a pasteboard square 6" by 6", covered with blue paper. The whole was placed on our little disk that could be rotated. The toy was hidden under the green box and the children taught to find it regardless of position, as in the previous experiment. In the critical trial, similar blue and green boxes, but this time on a green background and with a toy under each, were substituted. 5C—The procedure was the same as the second except that Hering grays, No 12 and No 25, were used instead of blue and green. With the youngest child, a girl of 23 months, a slightly modified set-up consisting of two light gray boxes and one dark gray box on a light gray background was used to make the factor of difference stand out as strongly as possible. In the critical trial this was changed to two dark boxes and a light box on a dark background. The results of 5A, 5B, and 5C are summarized in Tables 4, 5, and 6 respectively.

TABLE 4
RESPONSES IN EXPERIMENT 5A
(15 cases)

Subject age in mos	Box-different-color dominant cue	Box-specific-color dominant cue
11 5-24	0	1
25-36	0	4
37-48	0	5
49-60	0	2
61-74	1	1
117-132	1	0

TABLE 5
RESPONSES IN EXPERIMENT 5B
(16 cases)

Subject age in mos	Box-different-color dominant cue	Box-specific-color dominant cue
11 5-24	0	0
25-36	0	4
37-48	0	4
49-60	0	5
61-74	0	0
117-132	3	0

TABLE 6
RESPONSES IN EXPERIMENT 5C
(14 cases)

Subject age in mos	Box-different-color gray dominant cue	Box-specific-color gray dominant cue
11.5-24	0	1*
25-36	0	3
37-48	1	3
49-60	0	4
61-74	0	0
117-132	1	1

*This was the 23-month-old girl who was given the set-up modified to reinforce the factor of difference

The trends in all three experiments are the same. If the results are combined, the specific color is dominant over the configurational difference for 97% (S E ±2.7%) of the children under 61 months old and for 25% (S E ±15%) of the children over that age The difference is 72% (S.E ±16%) in a direction *opposite* to the one deduced from the Gestalt principles. This is in line with the apparent trend in the preceding experiment. Together, Experiments 3, 4, and 5 would seem to show that a configurational difference in color, independent of the specific colors involved, can be used as a cue at an age when the dominance of position makes it difficult for the child to use color at all, that such a configurational difference may reinforce strongly the use of color as a cue; but that, if the configurational factor as a cue comes into conflict with a specific color, the latter is dominant with the younger children and more dominant the younger the children These experiments have disclosed a realm of perception in which the specific factors are ontogenetically prior to the configurational ones, a trend of development

opposite to the one discovered by the experiments upon the absolute and the relative discrimination of grays

Experiment 6 The fact that none of the 56 children in the critical trials of Experiment 3 chose any of the three out of five boxes with no cues in their favor is a type of consistency that is important but not so very surprising In Experiment 1, however, we have a slightly different situation Every box has a cue in its favor, and inconsistency is merely a matter of choosing first on the basis of one cue and then on the basis of another. Yet, only 4% (S E ±3%) of the choices of the children 11 5-60 months of age failed to be consistent. This almost perfect individual consistency coupled with only a general group relationship between type of cue used and age has two possible explanations

1 Individuals belong to types In each type a certain cue is completely dominant Certain types are more or less characteristic at certain ages. The consistency is explained by the complete dominance of the cue

2. No one cue is completely dominant The first choice is made after more or less of a conflict The age of the subject is one factor in determining the outcome of this conflict. A semi-transient combination of circumstances is another. If the cue tentatively selected leads to a solution, it tends to become completely dominant in similar situations We found consistency, because reward reinforces the dominance of a cue and the child was always rewarded in the critical trials.

The purpose of this experiment was to decide between these possibilities. We took 13 children, scattered throughout the age range, each of whom had responded consistently ten minutes previously, and put them through an experiment exactly similar to Experiment 1, except that there were no toys under the boxes in the critical trials The result was that the number of choices falling into the inconsistent categories increased to 31% of the total choices Since only 50% (S.E ±14%) of the true number of inconsistent choices would be expected to fall into these categories and since every one of the choices fell into a category different from the one ten minutes previous, we may conclude that removal of reward changes the behavior in this series from almost perfect consistency to almost perfect inconsistency. This indicates that the second of the two possibilities outlined above is, in all probability, the correct explanation.

IV. Discussion

The results of these experiments suggest a way in which future research will be able to discover that apparently random behavior is following perfectly definite laws. They also suggest certain interesting relationships between the problems of learning, transfer of training, and insight. It would seem that in a new situation there is a conflict among reactions to cues from preceding situations. These cues may be quite complex even with young children. Our experiments have pointed the way towards the ascertainment of the manner in which the outcome of this conflict is determined by the age of the subject, the structure of the situation, and the results of previous reactions. If the set-up is such that the reactions to the dominant cue happen to be reinforced, the result is called either transfer of training or insight.[13] If the set-up is such that the reactions to the dominant cue happen to be frustrated, these reactions are weakened until the reactions to the next most dominant cue operate. The repetition of this process often gives the illusion of random behavior. If the cue that the experimenter has decided to call correct is made relatively stronger, the result is called learning. Since the various trials in a learning series are only relatively similar, this process is really the setting up of a specific type of transfer of training. Thus it can be seen that the cue, as a channel of transfer of training formed by the operation of an environmental trend towards consistency upon a native level of neural organization, is a central, unifying point of attack upon the problems of random behavior, learning, transfer, and insight.

Summary

A combination of the method of critical trials with the direct delayed reaction resulted in a new technique which enables the experimenter to dispense with the 20 to 60 training trials involved in the older method of critical choices and which promises to be very useful, especially with young children, in attacking genetically the problem of stimulus definition.

[13]In our first experiment where all cues were reinforced, the behavior of the younger children was nearly completely consistent demonstrating almost perfect, though different, insights or transfers. It was more difficult to detect consistency in the behavior of the older children. It might seem that their behavior was less insightful. Our hypothesis is that these children were responding to cues more complex than the ones we were studying.

In the experiments reported the attack upon the problem of the definition of the stimulus was the determination of some of the factors which govern the dominance of cues. It was found that almost every choice in a series of altered situations was made on the basis of definite cues from previous "similar" situations. The different-color, a configurative difference not dependent on the specific color involved, could be used as a cue by children, even in the early ages where they had difficulty in learning to use color as a cue at all. But if this cue conflicted with a specific color, the latter was dominant with the younger subjects. The dominance of cues was found to be a function of

1 *The age of the subject* In the situations used in these experiments position was the earliest cue; a simple configuration next; and color the last. The older children seemed to be responding to a much more complex situation than were the younger

2. *The structure of the situation.* Increasing the distance between the two boxes weakened the cue "position-relative-to-the-other-box" and strengthened the cue "position-relative-to-the-subject" A yellow box, as distinguished from four red boxes, seemed to be a stronger or more primitive cue than a yellow box, as distinguished from a single red box.

3. *The outcome of previous choices in "similar" conflict situations* A change from the reward of every choice in a series of critical trials to no reward changed the behavior from almost complete constancy to almost complete variability of dominant cue.

References

1 Brian, C R, & Goodenough, F L The relative potency of color and form perception at various ages *J Exper Psychol*, 1929, 12, 197-213

2 Edgerton, H A., & Paterson, D. G A table of standard errors and probable errors of percentages for varying numbers of cases *J Appl Psychol*, 1926, 10, 378-391

3 Gellermann L W The influence of instructions in human maze learning *Psychol Bull*, 1932, 29, 560

4 Hertz, M Wahrnehmungspsychologische Untersuchungen am Eichelhaher *Zsch f vergl Physiol*, 1928, 7, 144-194

5 Jones, M C A laboratory study of fear the case of Peter *Ped Sem*, 1924, 31, 308-315

6 Klüver, H Equivalence of stimuli in the behavior of monkeys. *J Genet Psychol*, 1931, 39, 3-28

7 Koffka, K The growth of the mind New York Harcourt, Brace, 1925 Pp xvi+383

8. LEEPER, R. The delayed reaction in children M A thesis, Clark Univ 1928

9 LURIA, A R [Experimental] psychology and the development of the child] *Nauchnoye Slovo*, 1929, 3, 77-97 (*Psychol. Abstr.*, 1930, 4, No. 376.)

10 PRATT, K C, NELSON, A K, & SUN, K. H The behavior of the new-born infant. *Ohio State Univ Stud Contrib. Psychol*, 1930, No. 10. Pp xiii+237

11 RIEKEL, A. Psychologische Untersuchungen an Huhnern *Zsch f Psychol*, 1922, 89, 81-115

12. TOBIE, H. Die Entwicklung der teilinhaltischen Beachtung von Farbe und Form im vorschulpflichtigen Kindesalter *Beihefte z f angew. Psychol*, 1927, 12, No 38 Pp viii+103.

13 USNADZE, D Gruppenbildungsversuche bei vorschulpflichtigen Kindern *Arch f. d ges Psychol.*, 1929, 73, 217-248

14 WATSON, J. B, & WATSON, R. R. Studies in infant psychology *Scient Mo.*, 1921, 13, 493-515

15. WHEELER, R H Readings in psychology New York Crowell, 1930. Pp 600.

16 YERKES, R. M, & YERKES, D N Concerning memory in the chimpanzee *J Comp Psychol.*, 1928, 8, 237-371

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LA PERCEPTION DES ENFANTS UNE ÉTUDE GÉNÉTIQUE EMPLOYANT LA RÉACTION RETARDÉE DE CHOIX CRITIQUE

(Résumé)

L'emploi de la réaction retardée directe pour éliminer les vingt à soixante épreuves d'entraînement dont il s'agit dans l'ancienne méthode des choix critiques a produit une nouvelle technique non-verbale qui donne des espérances

Dans six expériences avec 98 enfants on a étudié les facteurs qui gouvernent la dominance des suggestions Presque chaque choix dans une série de situations changées s'est montré basé sur des suggestions définies remontant à des situations antérieures "semblables" La couleur différente, une suggestion configurative indépendante de couleurs spécifiques, pourrait être employée par les enfants très jeunes. Si celle-ci était en conflict avec une couleur specifique comme suggestion, la dernière dominait chez les jeunes sujets. La dominance de la suggestion s'est montrée une fonction de

1 L'âge du sujet La position, une configuration simple, et la couleur ont constitué l'ordre génétique trouvé dans ces tests Les enfants plus âgés semblaient répondre à une situation beaucoup plus complexe

2 La structure de la situation. Une plus grande distance entre les boîtes a renforcé la position absolue aux dépens de la position relative Le jaune distingue de quatre rouges a été une suggestion plus forte que le jeune distingué d'un rouge

3 Le résultat des choix antérieurs L'enlèvement de la récompense

d'une série d'épreuves critiques a changé le comportement d'une constance presque complète à une variabilité presque complète de la suggestion dominante

On discute les implications des résultats pour les théories de l'apprentissage, le transfert de l'entraînement, et la compréhension

MILLER

DIE WAHRNEHMUNG DER KINDER EIN GENETISCHES STUDIUM MIT DER KRITISCHEN WAHL UND DER VERZOEGERTEN REAKTION

(Referat)

Durch die Anwendung der verzogerten Reaktion, um die zwanzig bis sechsig Trainingubungen, welche bei der alten Methode der kritischen Wahl notig waren, auszuschalten, wird eine neue versprechungsvolle, nicht-verbale Methode gebraucht

Die Faktoren, die das Herrschen der Fingerzeige beeinflussen, wurden in sechs Experimenten mit 98 Kindern untersucht Fast jede Wahl in einer Reihenfolge von veranderten Situationen beruhte auf bestimmten Fingerzeigen aus fruheren "ahnlichen" Situationen Der Ausdruck "eine andere Farbe" (ein Gestaltfingerzeig), der unabhangig von bestimmten Farben war, konnte auch von sehr jungen Kindern gebraucht werden Wenn dies in widerstreit mit einer bestimmten Farbe als einem Fingerzeig geriet, war der Fingerzeig bei den jungeren Kindern vorherrschend Das Vorherrschen vom Fingerzeig stellte sich heraus als eine Funktion:

1 Vom Alter des Kindes Stellung, eine einfache Gestalt, und Farben machten die genetische Reihenfolge, die in diesen Tests gebraucht wurde Die alteren Kinder schienen auf eine weit komplexere Situation zu reagieren.

2 Von der Struktur der Situation Grossere Entfernungen zwischen den Schachteln verstarkten die absolute auf Kosten der relativen Stellung Die unterscheidung des Gelben aus vier Roten war ein Fingerzeig starker als die Unterscheidung des Gelben von einem Roten

3 Vom Ergebnis fruherer Wahlen Das Entfernen der Belohnung von einer Reihenfolge kritischer Wahlen veranderte das Verhalten von der fast vollkommenen Bestandigkeit bis zur fast vollkommenen Veranderlichkiet des vorherrschenden Fingerzeiges

Die Folgerungen aus den Ergebnissen in bezug auf Theorien des Lernens, das Uebertragen von Uebung, und Einsicht werden erortert

MILLER

CONGENITAL CATARACT AND UNLEARNED BEHAVIOR*[1]

From the Psychological Laboratory of the University of Virginia

WAYNE DENNIS

INTRODUCTION

We have been interested for some time in the possibility of submitting to experimental attack the topic of human instincts defined as unlearned behavior. The unlearned behavior of the human being has for too long been left to the armchair investigator. In our opinion the experimental approach is possible. While several recent studies of "maturation" are inclined in this direction they unfortunately fail to distinguish between the maturation of a response and the maturation of the ability to learn the response. The investigation of unlearned behavior in human subjects is therefore almost without precedent and without methods.

In casting about for a condition that Nature herself may occasionally impose which removes or minimizes certain possibilities of learning, we thought at an early date of the probable usefulness of cases of recovered congenital cataract. In these cases there exists a deprivation of many visual experiences which may be brought to an end by the surgeon at nearly any desired time. The cases seem at first glance to offer an excellent opportunity for the psychologist to discover what responses to visual stimuli are capable of development in the absence of vision.

As a consequence of this interest we shall submit below a brief survey from the point of view of unlearned behavior of cases of recovery from congenital blindness reported to date. Before entering upon this summary, however, a few introductory considerations must be presented. We may say, in the first place, that observers

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[1]We are indebted to the Institute for Research in the Social Sciences at the University of Virginia for providing the freedom from teaching and the access to bibliographic sources which made this study possible. We must also thank Dr. Wilmer of the Wilmer Institute of the Johns Hopkins University for valuable counsel.

of cataract cases usually have been relatively uninterested in unlearned behavior and hence their observations upon that point are incidental The chief purpose of many students of recovery from congenital blindness has been to seek an answer to "Molyneux's query." Molyneux wrote Locke propounding the question of whether a person who was born blind and who had learned by touch to tell the difference between a cube and a sphere would also be able immediately to tell them apart by sight The bearing of this question upon theories of space perception need hardly be mentioned here It was not long after the placing of this question that many sought to answer the query, or others related to it, through the study of these cases In most case reports, the interest of the observer has centered largely on the visual recognition of tactual forms Excellent reviews of the case reports chiefly from the standpoint of this interest will be found in the papers of Bourdon and Hippel With reference to Molyneux's query it may be said that the general conclusion which has been arrived at is that some persons submitted to operation for congenital blindness can recognize some objects visually but that these cases do not meet the conditions of the problem because they have not been, strictly speaking, blind Since this conclusion was reached, psychological interest in the topic has somewhat decreased, there being fewer entries in the bibliography from 1900-1925 than from 1875-1900 Our latest title is dated 1915

In preparing our present bibliography we sought to make it include all scientific reports concerning the behavior of recovered congenital cataract cases, but nevertheless we were forced to omit four references which are cited in Helmholtz' *Physiological Optics* (translation edited by J. P C Southall) Two of these (Hofbauer and Grant) were excluded because they were too incomplete for identification of the publication and two of them (two papers by Uhthoff) because they were in publications to which we could not obtain access. We have omitted several accounts which have occurred in popular magazines in the past five years as they are of such doubtful value In addition to congenital cataract cases we have included one reference to recovery from non-congenital cataracts and one reference to recovery from blepharospasm These cases present some of the same opportunities for psychological study as do the cases of blindness from birth, and the references cited will introduce one to the literature on this allied subject

Preliminary Considerations

The data from cataract operations cannot be evaluated without a preliminary consideration of the nature of the cases In the first place, it is necessary to point out that none of the patients is ever completely blind. The lens is never so opaque but that some light, as for instance that received when the subject is looking at the sun, is transmitted to the retina. Thus nearly all subjects can distinguish temporal brightness differences and many can see well enough to follow lights or to locate objects, windows, etc Since the cataracts vary widely in their extent, location, and opacity, there are accordingly wide differences in the vision of persons with cataracts Some individuals, however, are reported to receive so little light upon the retina as to be unable to see colors (scotopic vision) even under very high external illumination, and it is obvious that detail vision, or vision for objects, is absent in the more severe cases But it is surprising that in some cases in which objects cannot be distinguished visually directed reaching may be quite accurate It is therefore important to know the exact vision and performance of any subject before the operation.

Secondly, the patients invariably or almost invariably suffer from a continual nystagmus which lasts for several weeks after the recovery of vision. It seems likely that the nystagmus is caused, somehow, by long exposure to poor illumination of the eye, as seems to be the case also in coal-miners' nystagmus and in the spasmus nutans of children, and that the ocular movements continue as a habit after the unfavorable lighting is replaced At any rate, nystagmus is a post-operative disability which must be taken into account in the study of these cases.

Thirdly, one must consider in interpreting the post-operative progress in vision the type of operation which is used in the removal of the cataract. If discission or needling is performed, the cataract is merely broken up and is left in the eye to be absorbed In this instance the recovery of vision requires a period of time which varies from subject to subject. Often several operations are necessary. On the other hand, if the cataract is removed by extraction, the optical system may be nearly as perfect immediately after the operation as at any later date, although of course the development of eye coordination and the elimination of nystagmus may progress gradually. Occasionally iridectomy is performed instead of either of the operations mentioned above.

Tests of Unlearned Behavior

1 *Visual Preferences* A survey of the case reports upon recovery from congenital blindness leave one with the impression that there is no uniformity whatsoever in the post-operative visual preferences of the subjects For almost any preference a corresponding antipathy may be found in another case. We cite below nearly all of the statements which can be found concerning this topic in the accounts of the cases in which vision for color and objects was thought to have been absent prior to the operation

Trinchinetti's case, a boy of 11, preferred yellow. In contrast with this, the case described by both Latta and Ramsay, a man of 30, upon first seeing yellow became so sick he thought he would vomit, but the feeling never recurred. In some agreement with the first account to be mentioned is Wardrop's report of a boy of 14 who preferred yellow gloves, but who was more pleased by other colors in other objects

Latta and Ramsay's case, mentioned above, and Trinchinetti's other case, a girl of 6, both preferred red. However, we shall soon find that at least one case (reported by both Miner and Heard) found red foods repulsive

Home's first case, a boy of 12, was at the beginning photophobic, while the cases of Vurpas and Egghi, a boy of 4 and a girl of 5, found the light agreeable. Other accounts show this same difference with respect to the agreeableness of light.

The woman, 29, studied by Russell thought everything was beautiful, although Miner and Heard's subject, a woman of 22, says.

> I could not bring myself to eat anything but milk, mashed potatoes or bread—they looked clean but toast or meat or eggs looked dirty and disgusting I could not eat tomatoes, beets or roast beef of which I had been very fond—they were so red and hard and the looks of them sickened me
> I persisted in throwing dresses and waists out of my closet because they were too gaudy

The latter individual thought that human faces were repulsive and that mouths were like black holes, whereas Franz says of his patient, a boy of 17, "The human face pleased him more than any other object presented to view" Latta reports that the man described by him took little esthetic interest in the human face.

In contrast to Ware's boy, 7, and Cheselden's boy, 13, who preferred objects which were smooth, Miner and Heard's case preferred blurred outlines

It is obvious that no adequate method of studying visual preferences has been used in any of these studies. Part of the divergence of the results is no doubt due to the diversity and unreliability of the measures of preferences, which consist almost entirely of casual questions and observations While the disagreement of the subjects argues against any universal unlearned preferences, we must conclude that the accounts are not decisive for the absence of such preferences because of the poor quality of the data. However, the survey reveals no reasons why the use of adequate research methods would not be fruitful.

2 *Reaction to Distance.* Some persons with not too severe cataracts are capable of reaction to distance even in the "blind" state If we exclude such cases, the evidence seems conclusive that an accurate appreciation of distance does not appear immediately following the operation. The most usual test to be used in this connection is that of placing an object in front of the subject and requesting him to reach for it The children observed by Vurpas and Eggli had no success in reaching for an orange Trinchinetti's child subjects likewise failed in a similar test Carpenter's case groped for objects The cases of Nunneley and of Russell are reported to have had no idea of distance Similar inaccuracy is reported by Ahlstrom, Fisher, Hirschberg, Raehlman, and Minor. It is interesting to note that two men between 60 and 70 who were operated upon by Lobanow and whose cataracts were not congenital but had existed for 17-21 years also were inaccurate in reaching for objects upon recovery from their blindness These cases as well as congenital ones seem to present good evidence that if any unlearned connection between reaching and vision exists it is either very temporary or of a low order of accuracy.

It can be rightfully urged by those who hold that some distance estimation is unlearned that the operation, in destroying the lens and thus the act of accommodation, destroys an essential part of the reacting mechanism. It is also true that no quantitative statement of accuracy has been obtained.

Some of the errors in distance estimation are amusing as well as interesting. The man described by Latta and Ramsay soon after

the gaining of his vision went up a flight of stairs taking two steps at a time without discovering his error. Heard and Miner's subject writes: "If I tried to walk with my eyes open I stepped so high every one laughed at me." The man described by Minor a year after one eye had been cleared of its cataract (the second eye was still unoperated) could chop wood better with his eye closed than with it open.

By way of postscript we may say that only two individuals (Nunneley's case and Home's second case) have agreed with the patient of Cheselden, who was the first to be described psychologically, that everything seemed to touch his eyes.

3. *Interest in Visual Experience.* The situation in this field is very similar to that which exists in the realm of visual preferences, that is, the individual cases differ enormously. The subject of Dor's observations, a man of 22, made very rapid use of vision. Other cases, too, show much interest in their newly acquired sensory field. For instance, Minor writes concerning the man of 40 reported by him: "With the exclamation, 'I can see' he became a changed man. His one object in life was 'to see.'" Russell's subject was overjoyed to find she could see, Schanz's case learned readily, Dufour's case was enlivened by sight, etc. On the other hand, the two children, 4 and 5, reported by Vurpas and Eggli did not react to light and continued for an unspecified length of time to act as in the past although their eyes were clear. Several months elapsed after the removal of the cataracts before Carpenter's 3-year-old subject came to use his vision as other children do. If the slowness of adaptation be attributed to immaturity in these cases, it cannot be so attributed in the case of the man of 21 concerning whom Albertotti writes: "He did not wish to try to use the visual sensations which he received and thus, left to himself, he returned some months after to the deplorable state in which he was before the operation" (namely, uninterested in anything). The sister, 33, of the young man previously mentioned as described by Latta and by Ramsay, in contrast with her brother, made little use of her newly acquired sight. Uhthoff in his account refers to a subject who showed little interest in his vision.

Such reports serve to emphasize the need for correlation with abilities, pre- and post-operative vision, previous habits, personality, etc. However, unless we assume that an instinctive factor has

been distorted by habit interference, these descriptions give no impression of a uniform native interest in the visual environment *qua* visual.

4. *Visual Fears.* We have been unable to find any report of fear either of a specific object or of the visual environment in general during the days immediately following the operation. There is some mention of fear in the article by Heard and in the monograph by Wardrop but not as one of the initial reactions. Particularly in the juvenile cases, it seems likely that shrinking and crying would hardly have been intentionally suppressed nor would they have escaped notice had they been present. The absence of fear is noteworthy in view of the fact that several studies in child psychology have recently shown that strange or unusual or unexpected objects elicit negative responses in many children. The behavior of the cataract cases probably indicates that a certain amount of visual experience with objects is necessary before any visual stimulus can function as "strange" or "unexpected." If this is so, one would expect the cataract cases to show fear toward visual objects only when some time had elapsed after their acquisition of detail vision. Unfortunately the case histories seldom cover a sufficiently long period of time, nor are they comprehensive enough, to test this deduction.

Discussion

The study of this body of interesting literature has been disappointing in that it is inconclusive with regard to our problem. To be sure, we have failed to find good evidence that visual preferences, interests, or fears are unlearned or that reactions to distance are unlearned. On the other hand, it may be urged that the negative results are not decisive for several reasons. The chief of these lies in the non-quantitative as well as in the incidental nature of the observations. On the whole, it seems to us that the literature which we have just cited weakens rather than strengthens the case for the existence of unlearned visually controlled coordinations beyond those present in the newborn, but we realize that this is a conclusion whose probabilities of correctness cannot be stated.

But, though it be concluded the cases which have been described have not yielded very significant data upon the topic of the maturation of behavior patterns, we are of the opinion that cases of con-

genital cataract may yet be of a great deal of service in this connection In reading the reports which we have cited one cannot escape the conclusion that adequate methods for the study of behavior, and particularly of the behavior of the child, have never been used with this material Studies of the visual preferences and of the visually controlled reaching of formerly blind people have never been quantitative or comparable from subject to subject and this criticism could be extended to all other topics of investigation encountered in the case reports. We feel that some of the methods which have recently been developed in child psychology would yield valuable data with these cases. This is true not only with reference to the problem of maturation but in respect to many other problems as well If, for instance, results with respect to the unlearned development of behavior prove to be negative, one has the opportunity of studying in these cases certain processes of learning which could never be studied in their entirety in the normal child because they cover too long a period of time Their usefulness in the investigation of true age differences in the learning of visual coordinations is also apparent.

We are convinced that the utilization of these "natural experiments" is entirely feasible In the course of a two years' interest in the observation of these patients we have found hospitals and ophthalmologists to be cooperative and the frequency of the cases to be greater than we had supposed. However, in order to study a case adequately one should be in a position to devote his entire time to it upon short notice. Ordinarily the experimental period is limited to the hospital period The ideal plan for the investigator would be to reside for a period of time in a large ophthalmological hospital, preferably one in which the method of extraction is commonly used because of the quicker improvement of vision in these cases.

Summary

We have indicated that some congenital cataracts constitute a nearly complete deprivation of vision and that the removal of the cataracts by operation furnishes an opportunity for the study of initial responses to visual objects at a variable interval beyond birth This set-up for a "natural experiment" suggests itself as being valuable as a method for the study of unlearned responses to visual

stimuli. It is also appropriate to other problems such as the study of visual learning at various ages with past experience nearly absent. We have reviewed the literature upon the effect of the removal of congenital cataracts from the standpoint of unlearned behavior and have found no positive evidence of an unlearned control of behavior by vision, but we have indicated reasons why this negative result may not be conclusive.

It is suggested that the application of adequate research procedures to cases of recovery from cataract may yield valuable data concerning the development of behavior and some of the requirements of such an investigation have been outlined

References

1. Ahlstrom, G. Beobachtungen uber das Sehenlernen eines mit guten Resultate operirten neunjahrigen Blindegeborenen *Skand. Arch f. Physiol*, 1895, 7, 113-122
2. Albertotti, J. Un cas de cataracte congénitale *Arch ital de biol*, 1884, 6, 341-356
3. Armaignac, H Le defaut d'usage d'un oeil pendant de longues années, est-il une cause d'amblyopie? *Rev. clin d'ocul*, 1885, 5, 209-221
4. Augstein, C Beobachtungen nach erfolgreichen Operation eines 15 jahrigen Blindgeborenen uber sein Sehenlernen *Klin Monatsbl. f. Augenhk*, 1913, 51, 521-526
5. Bourdon, B La perception visuelle de l'espace Paris. Schleicher Frères, 1902 Pp 362-391.
6. Carpenter, W B Mental physiology New York Appleton, 1875 Pp. 180-181
7. Cheselden, W Observations made on a young gentleman who was born blind or who lost his sight so early that he had no remembrance of ever having seen and was couched between 13 and 14 years of age. *Phil. Trans*, 1728. Reprinted in Helmholtz' *Physiological Optics*
8. Critchett, G. Operation for congenital cataract on an adult *Medico-chir. Trans*, 1855, 38, 51-58.
9. Dor, H. Guérison d'une aveugle de naissance *Rev. gén d'ophth.*, 1886, 5, 481-483.
10. Dufour, M Guérison d'un aveugle-né *Bull de la Soc med de la Suisse rom*, 1876, 10, 58-63, 79-87, 102-113
11. Fisher, J H. Observations on the learning of vision after a successful operation at the age of six years, in a congenitally blind patient *Ophth Rev*, 1914, 33, 161-165
12. Francke, V Das Sehenlernen eines 26 jahrigen intelligenten blindgeborenen. *Beitr. z. Augenhk.*, 1894, 16, 463-490.
13. Franz, J C. A Memoir of the case of a gentleman born blind, and successfully operated upon in the 18th year of his life, with physiological observations and experiments. *Phil. Trans*, 1841, 59-68

14 GRAFÉ, A Note sur un aveugle de naissance, opéré de la cataracte a l'âge de quinze ans *Rev. scient*, 1892, 50, 67-75.

15 HEARD, M K When the blind see a case report *Woman's Med. J Cincin*, 1915, 25, 79-81

16 HEYFELDER, O. Die Kindheit des Menschen *Dtsch Zsch f d Staatsarzneikunde*, 1857, 11, footnote page 314

17. HIPPEL, A v Beobachtungen an einem mit doppelseitiger cataract-geborenen erfolgreich operierten Kinde *Graefe's Arch f. Ophth*, 1875, 21, 101-131

18 HIRSCHBERG, J Eine Beobachtungsreihe zur empiristischen Theorie des Sehens *Graefe's Arch f. Ophth*, 1875, 21, 23-42

19 HOME, E An account of two children born with cataracts in their eyes to show that their sight was obscured in very different degrees, with experiments to determine the proportional knowledge of objects acquired by them immediately after the cataracts were removed *Phil Trans*, 1807, 83-92

20 LATTA, R Notes on a case of successful operation for congenital cataract in an adult *Brit J Psychol*, 1904, 1, 135-150

21 LOBANOW, — Verlernen des Sehens durch Katarakt-Erblindung *Klin Monatsbl f Augenhk*, 1900, 38, 676-677

22 MINER, J B A case of vision acquired in adult life *Psychol Rev, Monog Suppl*, 1905, 6, No 4, 102-118.

23. MINOR, J L Learning to see at 40. *Trans Amer. Ophth Soc*, 1897-98, 8, 460-468

24 NUNNELEY, T On the organs of vision London Churchill, 1858 Pp. 30-33

25 RAHLMANN, E Psychologisch-physiologische Studien über die Entwicklung der Gesichtswahrnehmungen bei Kindern und bei operierten Blindgeborenen *Zsch. f Psychol u Physiol d Sinnesorg*, 1891, 2, 53-96

26 RAMSAY, A. M. Case of a man blind from congenital cataract who acquired sight after an operation when he was 30 years old *Trans Glasgow Pathol & Clin Soc*, 1901-1903, 9, 180-185

27 RUSSELL, E R Report of an interesting case of bilateral congenital cataract, in patient 29 years old *Charlotte (N C) Med J*, 1913, 67, 226-227.

28. SCHANZ, F Über das Sehenlernen blindgeborener und später mit Erfolg operierter Menschen *Zsch f Augenhk*, 1904, 12, 753-762.

29 SILEX, P Eigenartige Sehstörungen nach Blepharospasmus. *Arch f Psychiat*, 1898, 30, 270-283

30. TRINCHINETTI, — Observations sur les premières impressions visuelles perçues par deux aveugles de naissance après l'opération de la cataracte *Arch des sci phys et natur de Genève*, 1847, 6, 336-337 (Abstracted from *Giorn dell'Instit Lombardo*, 1847, *fasc* 47 et 17.)

31 UHTHOFF, W Wietere Beitrag zum Sehenlernen blindgeborener und später mit Erfolg operierter Menschen sowie zu dem gelegentlich vorkommenden Verlernen des Sehens bei jungeren Kindern, nebst psychologischen Bemerkungen bei totaler kongenitaler Amaurose *Zsch. f Psychol u Physiol d Sinnesorg*, 1897, 14, 197-241

32. VURPAS, C, & EGGIT, H Quelques recherches psychologiques sur les sens de la vue chez deux enfants operés de cataracte double congénitale. *Ann méd-psychol*, 1896, Ser 8, 4, 14-26

33 WARDROP, J. History of James Mitchell, a boy born blind and deaf, with an account of the operation performed for the recovery of his sight London Murray, 1813 Pp 52

34 ———. Case of a lady born blind who received sight at an advanced age by the formation of an artificial pupil *Phil. Trans*, 1826, 529-540.

35 WARE, J. A case of a young gentleman, who recovered his sight when 7 years of age after having been deprived of it by cataract before he was a year old, with remarks *Phil Trans*, 1801, 382-396

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LA CATARACTE CONGÉNITALE ET LE COMPORTEMENT NON APPRIS

(Résumé)

On a indiqué que quelques cataractes congénitales constituent une perte de vision presque complète et que l'enlèvement des cataractes par une opération fournit l'occasion d'étudier les reponses initiales aux objets visuels à un intervalle variable après la naissance Cet arrangement pour "une expérience naturelle" se suggère comme méthode de valeur pour l'étude des réponses non apprises aux stimuli visuels On pourrait l'employer aussi pour d'autres problèmes tels que l'étude de l'apprentissage visuel à divers âges, l'experience passée étant presque absente On a résume ce qu'on a écrit sur l'effet de l'enlèvement des cataractes congénitales au point de vue du comportement non appris et l'on n'a trouvé nulle évidence d'un contrôle non appris du comportement par la vision, mais on a indiqué des raisons pourquoi ce résultat négatif peut être non conclusif

On suggère que l'application de procédés adéquats de recherche aux cas de guérison d'une cataracte peut céder des données de valeur sur le développement du comportement et l'on a résume quelques conditions essentielles d'une telle investigation

DENNIS

ANGEBORENER KATARAKT UND UNGELERNTES VERHALTEN

(Referat)

Wir haben darauf hingewiesen, dass einige angeborene Katarakten einen fast vollkommenen Verlust des Gesichts verursachen, und dass die operative Entfernung der Katarakten eine Gelegenheit zum Studium der ersten Verhaltungsweisen in Hinsicht auf optische Gegenstande in einem veranderlichen Zeitraum nach Geburt geben kann Dieses "Naturexperiment" zeigt sich als sehr wertvoll zum Studium der ungelernten Reaktionen auf optische Reize. Es ist auch zweckmassig fur andere Probleme, wie die Untersuchung optischen Lernens in verschiedenen Altern, wo vergangene Erfahrungen fast fehlen Wir haben die Fachliteratur uber die Wirkung

der Entfernung von angeborenen Katarakten vom Standpunkt ungelernten Verhaltens untersucht, und haben keine positiven Beweise dafur, dass es eine ungelernte Kontrolle des Verhaltens durch das Gesicht gibt, aber wir haben Grunde angegeben, warum dieses negative Ergebnis nicht endgultig sein durfte

Es wird vorgeschlagen, dass die Anwendung einer adaquaten Versuchsanordnung auf Wiederherstellungsfalle von Katarakten wertvolles Material hinsichtlich der Entwicklung des Verhaltens an die Hand geben mag. Einige der Forderungen einer solchen Untersuchung sind vom Verfasser aufgestellt worden.

DENNIS

THE ADAPTIVE BEHAVIOR OF INFANTS IN THE UTILIZATION OF THE LEVER AS A TOOL: A DEVELOPMENTAL AND EXPERIMENTAL STUDY*

From the Yale Clinic of Child Development

HELEN M. RICHARDSON

INTRODUCTION

The experiments described here were part of a larger investigation of the growth of adaptive behavior in infants.[1] A more elaborate account of the major portion of this study has been published in *Genetic Psychology Monographs* for September-October, 1932.

Statement of Problem The problem was to analyze the development of adaptive behavior from the age of 28 weeks through 52 weeks in situations calling for a very simple use of tools to attain an objective. The tools were of a type that is physically connected with the objective. a string tied to a remote toy, or a horizontal lever that could be rotated to bring in reach a toy carried on the far end. A grill served as a barrier which necessitated the use of the tool to secure the remote objective. The string experiments are described in the monograph mentioned above The present paper deals with the lever problems In addition to analysis of development, the procedure permitted a comparison of behavior before and after demonstration of rotation.

Historical Summary Investigations of adaptive behavior in analogous lever problems have made use of animal subjects almost exclusively and have not emphasized the developmental aspect of the behavior

Shepherd (15), with 11 rhesus monkeys as subjects, employed a light wooden lever 18 5 inches long, its near end being attached by hinges to a base 4 inches from a grill The lever was inclined away

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[1]This study was made at The Yale Clinic of Child Development in 1930-1931 The writer gratefully acknowledges the advice and assistance of Dr Arnold Gesell and Dr Helen Thompson in planning and conducting the study, and their helpful criticism of the manuscript

from the grill at an angle of 45 degrees. By moving it forward in a vertical plane, food on the far end could be brought in reach All but one of the subjects succeeded in the first trial The chief difficulty was adjustment of the hand to the proper opening rather than failure to attack the apparatus in the proper manner. In a similar later experiment Shepherd (16) found that a cat was unsuccessful. He concludes that the monkeys gave evidence of adaptive intelligence and that the cat did not At the same time he admits that the apparatus may not have been sufficiently well suited to the cat's motor equipment

Nellmann and Trendelenburg (13) call attention to the fact that Kohler's diagonal string experiment (11, p. 207) is essentially a lever problem in which the pivot is distant, the long arm serves as a handle, and the objective is between the end of this arm and the pivot The chimpanzees' behavior in this situation furnishes one of Kohler's strongest arguments for "insight" Nellmann and Trendelenburg use the term "primary solution" to cover a case in which a problem, on the very first occasion of its being encountered, is solved without aid of overt imitation, "trial and error," or "being put through." With a horizontal lever pivoted at the near end, to be pulled with the hand between the pivot and the objective, they found that a rhesus and a pavian monkey achieved primary solutions. Though they admit the possibility of transfer to this situation from similar use of a slender branch in wild life, they emphasize the fact that such transfer to the laboratory problem would show a significant capacity for adaptation. In a turntable experiment, likewise, they observed primary solutions by both the rhesus and the pavian, preceded by two or three testing movements

Drescher and Trendelenburg (3) report that in turntable experiments a Java ape, a young rhesus, chimpanzees, and orangs gave primary solutions, but cats were unsuccessful One cat accidentally brought the food almost in reach, but seemed unable to continue the adaptive procedure

Yerkes (19), with the gorilla Congo, used a turntable in studying the delayed reaction Congo's ability to adapt to the turntable was not called in question.

Guillaume and Meyerson (6) outline a series of categories to which tools for securing remote objects may be assigned According to their classification, levers like those with which we are concerned

are tools connected with the object and subjected to mechanical conditions. Guillaume and Meyerson used two levers in which two sticks formed a cross that turned about a central point, the objective being fastened to the extremity opposite the cage. In the case of one of these levers, an obstacle limited the possibility of rotation to one direction. A third lever was similar to the one described by Shepherd An account of their experiments with chimpanzees (7) stresses the great adaptability of the animals and the authors' feeling that no simple mechanical explanation of the behavior is possible

Adams (1), in his studies of cats, employed three types of levers: one similar to Nellmann and Trendelenburg's, and two with a pivot between the objective and the handle, so that the force had to be applied in a direction different from that in which the objective should move Adams emphasizes the importance of accustoming the animals to the experimenter and the experiment room and of adapting the apparatus to the motor equipment of the subjects His subjects showed great individual differences in motivation and in adaptive behavior. Two out of eight were successful with the first type of lever and apparently mastered the problem after two trials. With the other two levers likewise two cats were completely successful One cat was successful in all three problems. Adams' conclusions from his whole series of experiments are that "motor and perceptual adaptation are indissolubly associated and develop concomitantly", that insight is "a special case of adaptation, both perceptually and behaviorally", and that what is often called trial-and-error learning might be called a "small insight" and that what is frequently called mental trial and error might be called a "big insight" He notes the harmony between his views and those of Hobhouse (9) and Tolman (18).

Kluver's (10) studies of the use of tools by monkeys include one diagonal-string problem (p. 239) similar to Kohler's and two complicated by extra strings. His two subjects were immediately successful in the simpler problem, achieved a slightly inferior solution in the second, and responded correctly after one error in the third. He notes that the characteristic first reaction of the monkey consisted in "doing something in the direction of the goal," that distances in the direction of the goal cannot be considered equivalent to distances of the same length in other directions, and that the

"properties of the field" changed rapidly under the influence of training

Studies of adaptive behavior in infants have used other techniques than lever problems. In Brainard's (2) series of experiments with his 30-months-old daughter there is a diagonal-string problem like Kohler's. The results were similar to Kohler's: the child pulled first in the direction of the string, then moved it along from one space of the grill to another until the objective came in reach.

Character of the Present Study. The present study makes a genetic approach to the question of adaptive behavior in these problems, not through comparing one genus with another, but through observing human infants at age intervals of four weeks during the six months' period in which they pass from incapacity to capacity to cope successfully with these problems. As was indicated in the writer's earlier monograph (14), the work of Gesell (4) has been influential in suggesting the problem and the procedure.

Method

Subjects. The subjects were the same infants as those used in the writer's other experiments (14) except that Girl F has been omitted. A detailed account of the constitution of the group (a "superior" rather than an average group) is given in the earlier monograph and is not repeated here. Each of the 10 boys and 5 girls was scheduled to be examined once every four weeks from the age of 28 weeks to 52 weeks inclusive. The total number of examinations actually given was 79, the number at each age ranging from 10 to 12. The average number for each infant was 5.3.

Apparatus and Mode of Procedure. The examination room and crib and the general method are described in the monograph above mentioned. Figure 1 shows the crib with a low table at one end and the grill barrier. The special apparatus for the lever experiments consisted of a light-gray board 27 x 19¾ x ½ inches, to which a red strip of wood 18½ x ¾ inches and ½ inch thick was attached by a pivot screw 5¼ inches from one end. A tray carrying a toy was fastened to the end of the longer arm of the lever. The tray was of colorless celluloid, 4 inches in diameter, with sides about 2 inches high, and was held in place by two crossed brass strips bent up and hooked over the sides. The pivot screw was loose enough to allow free rotation of the lever. The pivot point was

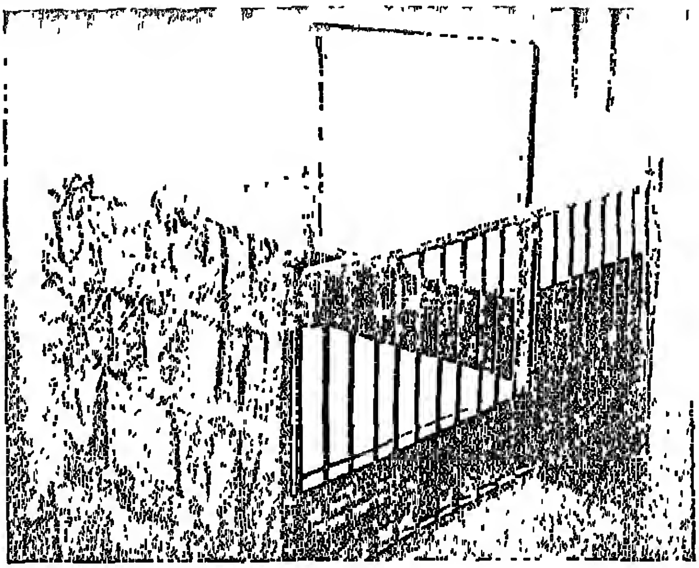

FIGURE 1
EXAMINATION CRIB WITH TABLE AND GRILL

marked by a washer ½ inch in diameter under the ¼-inch head of the brass screw The board was to be placed on the table top first with the lever in position A (Figure 2, *a*) From this position the tray could be brought in reach or to the grill by rotating the lever counterclockwise, either by pushing the short arm to the right or by pulling the long arm to the left. A nail in the board near the right-hand edge of the far end of the lever prevented clockwise rotation from position A. Figure 2, *b*, shows a second method of presenting the lever, which will be designated position B

Before any experimentation began the infant had been accustomed to the examination situation in a "warming-up" period, and before the lever was presented he had been through a series of string-pulling experiments and had been in the experiment room from 10 to 45 minutes. His mother's presence was permitted if it seemed necessary to put him at ease

At the appropriate time in the series of experiments (14, p 231), the lever board was laid on the table behind the grill, in full view of

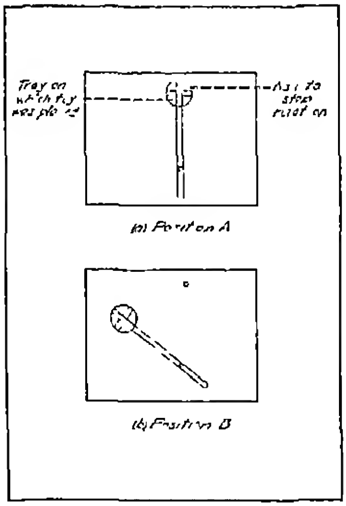

FIGURE 2
LEVER BOARD, SHOWING LEVER IN POSITIONS A AND B

the infant, who was in the crib at the time The lever was in position A and the infant was seated directly in front of the lever A small handbell[2] was rung by the Examiner, and, while the infant was reaching for it, the bell was moved down to the end of the lever, jingled again, and set on the tray The infant's behavior determined the length of time allowed for a trial, which varied from 25 seconds for those at 28 weeks who merely sat and stared to about 5 minutes for one at 48 weeks who tugged and rotated much. If the "lure" were not brought in reach from position A, the Examiner visibly rotated the lever to position B, rang the bell again, and again set it on the tray. If success were still lacking, the Examiner gave a demonstration by twice rotating the lever, with her hand on the short arm, between position A and a position with the tray touching the grill The lever was then left in position B. In 5 of the 79 examinations, the demonstration was followed by a re-presentation in position A Success in A or B was followed by a re-presentation as long as interest seemed to warrant it.

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[2]The hand bell was similar to those used in Gesell's developmental examinations (4, Figure 18)

Occasionally in these re-presentations it seemed desirable to substitute another lure for the bell, when it appeared that the latter had lost its motivating efficacy. Other small toys used for this purpose were a blue celluloid automobile, a roly-poly doll, a yellow wooden duck with red wheels, and a flame-colored celluloid rattle with black markings that suggested a fish.

A second trial when the first was a failure was given to one infant at 32 weeks, to one at 40 weeks, to two at 44 weeks, to four at 48 weeks, and to one at 52 weeks. All but one of these second trials were in position B and consisted in restoring the lever to position B after it had been turned to A Only two of these second chances brought success These two were at 48 weeks

Time records were kept by the Examiner with a stop-watch, and are available for most of the trials A running account of the behavior was dictated to a stenographer who was stationed behind a one-way-vision screen.

Treatment of Results The number of subjects at each age permits giving a quantitative form to the results The number of infants in whose records a given behavior item occurs at a given age in a given situation has been counted, and these frequencies, divided by the number of infants examined at the age in question, form the basis of the percentages that appear in the tables and graphs of results. Some of the most significant aspects of the behavior, however, call for descriptive rather than quantitative treatment

Analysis of the Material Results and Discussion

Influence of Age on the Behavior Table 1 shows for each infant at each age the situations that were presented and the number of successes in each

The results shown in Table 1 are roughly summarized in Figure 3, which does not take account, however, of the number of successes by each infant. This graphic presentation of results suggests that age or development bears an important relation to success and that an important step in maturation occurs between the ages of 40 and 44 weeks.

To ascribe this improvement with age to maturation more than to specific "practice effects" from trials at earlier ages is in accordance with the conclusions of Gesell and Thompson (5) from their studies of learning and growth by the method of co-twin control

TABLE 1

TRIALS AND SUCCESSES TABULATED BY AGES, SITUATIONS, AND INFANTS

Each dash (-) indicates one failed trial. Numerals indicate number of successful trials. Blank space indicates that the situation was not presented

A—position A before B or demonstration *A*(*B*)—position A after B, before demonstration *A*(*D*)—position A after demonstration
B—position B before demonstration *B*(*D*)—position B after demonstration

Infant	28 weeks			32 weeks			36 weeks				40 weeks				44 weeks					48 weeks					52 weeks				
	A	B	B(D)	A	B	B(D)	A	A(B)	B	B(D)	A	A(D)	B	B(D)	A	A(B)	A(D)	B	B(D)	A	A(B)	A(D)	B	B(D)	A	A(B)	A(D)	B	B(D)
Boy A																				2					4 -				
Boy B	-	-	-	-	-	-	-		-	-	-		-	-	-			1 -							-	-		1 -	
Boy C	-	-	-	-	-	-	-		-	-	-		-	-						1			- 2 -		-		5	-	
Boy D	-	-	-				-	- 1 --	2		-		-	-	-			-	-	-			-	-	-			-	-
Boy E	-	-	-	-	-	-			-	-					-			-	-						-			-	1 - 1
Boy F	-	-	-	-	-‡	-			-	-	-		--	-	2 -			- 2 -	2 --	- 4 --		-	3 -	-	-			-	---
Boy G	-	-	-	-	-	-																							
Boy H				-	-*	-														-			--	-	-	-	-	1	-
Boy I				-	-	-	-		-	-		-	1 - 2		4 -					-			2 --		3 - 3				
Boy K	-	-	-	-	-	-	-		-	-	-		-	-	-			1 -	-										
Girl A	-	-	-	-			-		-	-					-		-	-	2	-			-	- 1 ---	-			--	1 --
Girl B	-	-	-	-	-	-	-		- 1	-	-		† 2	-	5 1						-	-	1	-	2				
Girl C				-	-	-	-		-	-	-		--	-	-	-		2							1				
Girl D	-	-	-				-		-	-	-		-	-	-			--	-	-	- 1 -		3						
Girl E				-	-	-	-		-	-	-		-	-	-			-			1 -		-	-	-	3		1	

‡Not counted in frequency tables, because of a flaw in the procedure
*In what appeared to be an attempt to grasp the short arm, H shoved this arm away, so that the tray was rotated to the grill, but he cried and made only a momentary gesture in the direction of the lure
†Left hand on long arm of lever once brought the tray in reach, but right hand pulling on short arm rotated it away

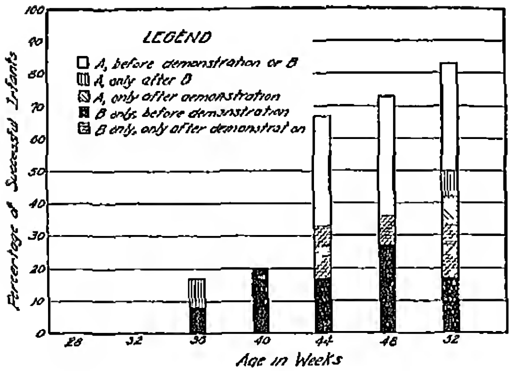

FIGURE 3
SUCCESSES IN POSITION A OR B BEFORE OR AFTER DEMONSTRATION

Though maturation is probably fundamental, however, it is not claimed that development is wholly uninfluenced by the infant's own activities. The daily manipulation of objects, even though it is non-specific with reference to a particular test situation, may very well contribute both to motor and to perceptual development. This

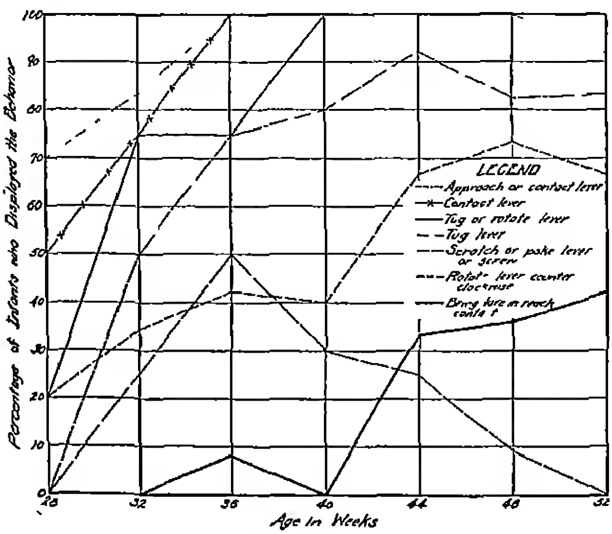

FIGURE 4
ANALYSIS OF ADAPTIVE BEHAVIOR IN POSITION A BEFORE DEMONSTRATION

point will be considered again after a more detailed presentation of results

Figure 4 gives a more refined analysis of the behavior in position A, showing some of the developments that precede success At 28 weeks only 70 per cent of the infants approached the lever and only 50 per cent contacted it Between 28 and 32 weeks there was a pronounced increase in the number who tugged at or moved the lever. The line representing the percentage who rotated the lever counterclockwise runs almost parallel to the line representing successes, though it runs at a greater height Inferior methods of approach and attack, such as scratching or poking at the lever or screw, reach a peak at 36 weeks and then decline in frequency

It seems unquestionable that *development of motor capacity* for getting through the grill is an important factor in adaptation to this situation. This conclusion is suggested by the data in Figure 4 and is likewise supported by the fact that at 32 and 36 weeks a much smaller percentage of infants moved the lever when it was in position B than when it was in position A (Table 2) In position B the near end of the lever is farther from the grill than in position A. The techniques used in the present study, of course, barely touch the surface of the problem of motor development The arm and hand movement which Halverson (8) designates as "approach" in his thorough study of cube prehension is undoubtedly involved in the capacity to get through the grill. Halverson found a shift from a preponderance of circuitous approaches to a preponderance of straight ones between 32 and 40 weeks and found at the same time a conspicuous lowering of the height of the approach In the lever experiments, before there can be success in position B by pulling on the long arm, the infant must be able to reach with secure grasp a position at least 6 inches inside the grill The average infant at 28 weeks can grasp a cube at this distance on the open table top (8), but it is another matter to accomplish this through a grill barrier. Before there can be success in position A by pushing on the short arm, there must be capacity for a rather fine wrist rotation "Wrist rotation" (supination and pronation involving hand, wrist, and forearm) appears in Gesell's 1928 norms (4) at seven months

Does the *perceptive attitude* toward these situations change with advance in age? The question of perceptive attitude requires the

TABLE 2

PERCENTAGE OF INFANTS WHO MOVED* THE LEVER IN POSITION A OR B AT 28 TO 40 WEEKS

Age in weeks	Position A: Number examined	Position A: Percentage who moved lever	B before demonstration: Number examined	B before demonstration: Percentage who moved lever	B after demonstration: Number examined	B after demonstration: Percentage who moved lever
28	10	20	10	20	10	10
32	12	75	10	20	11	18
36	12	75	12	33	11	9
40	10	100	10	90	9	22

*Moving includes rotating, tugging, and pushing.

making of inferences from the observable behavior. Here our treatment must be largely descriptive and only roughly quantitative

Doubtless one should not think of the lever and the lure as the sole potential stimuli to action There are also the grill, the sides of the crib, the platform, not to mention the Examiner, the chair on which the infant may be seated, and the infant's own person The hands of the infant may grasp the grill rods (true of 50 per cent at 28 weeks), he may pull himself toward the grill, he may turn to the side rail, creep, or pull himself to standing (Table 3). Usually, however, the lever and lure appeared to be conspicuous and focusing figures in the situation, at least for a brief time

TABLE 3
LOCOMOTOR ACTIVITY (POSITION A)

Age in weeks	Percentage who turned to crib rail, crept, or pulled to standing	Percentage who pulled to standing
28		
32		
36	17	8
40	30	10
44	58	25
48	64	64
52	92	92

The outline of possible perceptive attitudes toward this configuration which is given below is admittedly from the point of view of the experimenter, but it is suggested by the behavior of the infant subjects Figure 4 furnishes some data for this section, also Table 4, which shows the number of successes in A and in B which were brought about by pushing on the short arm alone, by pulling on the long arm alone, and by a combination of these two methods.

1 The bell may receive attention to the exclusion of the lever. This does not appear very likely, on account of the size, color, and position of the lever At 28 weeks 2 infants out of 10 are not reported as fixating or approaching the lever in position A, and 5 are not reported to look at or approach it in position B At 32 weeks these numbers are reduced to 1 out of 12 in A and 2 out of 10 in B At 36 weeks one infant apparently did not regard the lever in position B No infant who failed to regard or approach the lever

TABLE 4

METHODS BY WHICH TRAY WAS BROUGHT IN REACH IN SUCCESSFUL TRIALS
(Positions A and B both before and after demonstration)

Age in weeks	Number of successful trials		Pushing on short arm only				Pushing on short arm, then pulling long arm				Pulling long arm only			
	A	B	A		B		A		B		A		B	
			No	Per cent	No.	Per cent	No	Per cent	No	Per cent	No	Per cent	No	Per cent
36	1	3	1	100									3	100
40		5							1	20			4	80
44	12	10	7	58	1	10	3	25			2	17	9	90
48	9	12	6	67	4	33	3	33	1	8			7	58
52	21	6	17	81	1	17	1	5	1	17	3	14	4	67

made any approach to the bell beyond leaning forward and grasping the grill

2. The lever may be an object of interest in itself, aside from its relation to the toy on the tray. We found evidence of this sort of behavior in our string experiments (14), but it was practically negligible after 44 weeks. In the lever experiments, the lever was frequently approached and grasped before the lure was set on the tray To be sure, the tray could have been considered a distant objective even then, and at times it was brought in reach and manipulated. Unfortunately, quantitative evidence cannot be given here

3 The lever may be considered a tool analogous to an unrestricted attached string (14), to be pulled directly in as a means to transporting the lure. Figure 4 shows the frequency of such direct tugging in position A In position B, similar pulling applied to the short arm resulted in rotating the lever toward position A. At 32, 36, and 40 weeks, all who moved the lever in position B pulled it in this manner at least once At 44 weeks this was true of 78 per cent of those who moved the lever from position B, at 48 weeks of 89 per cent, and at 52 weeks of 62 per cent At these ages there were an increasing number who reached the longer arm of the lever and pulled on it. Though the fruitless direct tugging on the short arm must be considered an error even if the infant is merely trying to draw out the lever and not the lure, may it not be considered a "good error," in Kohler's words (11, p. 194), and considered the mark of an inference, though a false inference? As Lindemann (12) says, the behavior was governed by the visual rather than by the physical structure of the situation Adams (1) might call this a "small insight." Tolman (18) might say that a certain postulation of the goal position was evidenced. A number of infants repeated these direct tuggings three or four times in position A, using right and left hands alternately This need not be considered a blind repetition of an error objects which appear to be fastened firmly do not always remain fast. After 44 weeks this direct tugging in position A declines in frequency.

4 When the infant in position B secures the lure by reaching beyond the pivot and pulling the long arm of the lever toward him while he eagerly watches the lure, he is not only using the lever as a tool analogous to an unrestricted attached string (the force being applied in the direction in which the lure is to move) he is also

responding correctly to the physical structure of the situation. But is this physical structure perceived? Usually it appears that the infant is merely reaching as near as possible to the lure. Increasing successes with the use of this method in position B may be due to increasing capacity for arm extension and to increasing interest in the remote, complex lure in preference to the near, simple stick. One may say that when the infant has sufficient motor maturity the dynamics of the situation favor success without observation of the function of the pivot being necessary The cases that come nearest to suggesting a rudimentary observation of this function are those of Girl E at 52 weeks and of Girl A and Boy J at 44 weeks. Girl E was the only one who at 52 weeks employed the method of rotating the lever by the long arm in position A, and she adopted this method in A after success with it in position B. In a third trial after two unhesitating successes in A, she got her hand first on the short arm of the lever and shifted it beyond the pivot before making the rotating movement. Girl A at 44 weeks in position B, in her second trial after the demonstration, began with one brief clockwise pull on the short arm, but shifted beyond the pivot and pulled in the long arm. Boy J at 44 weeks in position A, having pushed the short arm until he could easily get his left hand on the long arm, began to pull on the long arm, but slipped below the pivot and sent the tray rotating away Promptly he shifted his grasp beyond the pivot and brought the bell to where he could secure it

5. To learn to apply force to the tool in a direction opposite to that in which the objective is to move appears to be a more difficult matter than to learn to apply it in the same direction, if one judges by the number who were unsuccessful in position A but successful in B. There is no evidence, to be sure, that this is more difficult than to perceive the function of the pivot. Successes in position A were almost all accomplished with at least an initial rotation of the short arm of the lever, and some successes in B were also of this type (Table 4).

In learning to bring the lure nearer by pushing on the short arm of the lever, was there trial with gradual elimination of errors, or observation and immediate repetition of successful moves?

It seems reasonable to suppose that the first successful movement of the short arm, at least in its beginning, must be of an exploratory nature or even accidental. How can the infant know in advance that

the lever is movable in this way until he has discovered the "physical structure" through trial in this or analogous situations? A successful procedure begun by trial or accident may sometimes be accompanied by observation of a relation between this procedure and its result and may be continued or repeated with "foresight" Perhaps one can infer that success is accompanied by observation of (or insight into) successful moves when there is a series of rather prompt and errorless successes, possibly preceded by a relatively long exploratory trial, but not preceded by a series of successful trials with gradually diminishing time and errors. One may infer that success has come without adequate observation (or insight) when it is not repeated (provided there is evidence that motivation continues) Our procedure did not provide the Thorndike type of experiments (17), with long time allowance and repetition at relatively short intervals, which show a gradual elimination of errors and reduction of time until the goal is reached with a minimum of time and movement. The time records that we have for some series of successes appear to be measures of motivation and emotional adjustment as well as of proficiency, and cannot be taken simply as indicative of presence or absence of insight. But our method brought out clearly enough in some cases the distinction between the infant who seemed able easily to repeat his successes and the one who did not.

An example of success apparently without insight in position A is provided by Boy D at 36 weeks, the only age at which he brought the lure in reach The first move was a turn of the hand on the tip of the lever which brought the tray in reach, and the bell was secured in 35 seconds after some difficulty in disentangling it from the tray and the grill In two following trials there was no success, although there was evidence of interest in the bell Sixty seconds were allowed for the first re-trial, then D was taken out of the crib for an interval and returned for another trial This time he began to fret and turned away after 20 seconds in which he had reached along the lever with right, left, then right hand without grasping it. If there was a flash of observation here, its results appear very short-lived.

More indicative of insight is the performance of Girl B at 44 weeks. Her protocols are reproduced here

> As soon as the lever board is in place, B gets her hand on the short arm of the lever and tries to tug it toward her She

rotates it about 40 degrees in the counterclockwise direction

The lever is returned to position A by the Examiner The handbell is rung B reaches for it with left hand as the Examiner moves it to the far side of the grill and sets it on the tray Right hand is also active B has turned the tray about 20 degrees before the bell is put in the tray Left and right hands alternately approach short arm, turning it She does not yet turn it more than 40 degrees in the counterclockwise direction, and occasionally turns it clockwise As she rotates it back and forth with her right hand, she eagerly watches the bell in the tray. Once she turns the lever as much as 90 degrees, so that the stick is parallel to the grill. After 80 seconds the tray, following trial rotations, is brought in contact with the grill, and B secures the bell.

The Examiner returns the bell to the lever in position A. B, with her right hand, turns the short arm about 40 degrees in the counterclockwise direction. She brings up her left hand. With her right in a steady movement she rotates the lever so that 20 seconds after the beginning of the situation the tray is near the grill. She secures the bell.

The bell is removed and set again on the tray in position A This time the first turn of the short arm is greater Five seconds after the beginning of the situation B has secured the bell and carried it through the grill

The fourth time the bell is put on the tray, B's turning of the lever brings the bell to where it can be barely touched with the tips of her fingers as she reaches through the grill She tries with both right and left hands, and finally with her right hand she takes hold of the tray and draws the bell in reach She secures the bell 45 seconds after the beginning of the situation.

The bell is removed and set on the tray again B's left hand tugs at the short arm, then her right hand, then her left hand again Then the right hand with one rotation turns the short arm so that the bell is brought close to the grill and secured 12 seconds after the beginning of the situation

If it were not for the long time reported on the fourth trial, due to B's struggling to secure the bell when it could be barely touched, our time records here would show a consistent low level after a very pronounced drop. The fruitless initial tugs in trial 5 show that the visual structure of the situation still had some influence

This deterioration of a performance when too many trials are given will be noted again in the case of other infants. It is also worth noting that what was learned by B was not a fixed reaction, using always the same motor mechanism, but a more or less variable means of attaining a goal. The protocols make it clear that this was true also of three out of the five infants who had a series of relatively errorless successes in position A at 52 weeks.

Table 5 gives in summary form an analysis of the performances of the successful infants at 44, 48, and 52 weeks, and may indicate in how many of the successful performances we can infer observation or insight. At 44 weeks Girl B is the only one who gives evidence of insight by a series of errorless successes. At 48 weeks we may count Boy A and Girl D. Boy G is a borderline case. The relapse of Girl B and Boy J after their brilliant performance at 44 weeks

TABLE 5

ANALYSIS OF SUCCESSFUL TRIALS IN POSITION A AT 44, 48, AND 52 WEEKS

Letters *a*, *b*, *c*, *d*, etc., indicate successful trials in order. *Indicates that the method was to pull on the long arm only. In non-starred trials there was at least an initial push on the short arm.

Age in weeks	Infants successful in position A	Successful trials: With no errors	With only one error	With only two errors	With more than two errors
44	Boy G	a*			b
	Boy J				a, b, c, d
	Girl B	b, c, d			a, e
	Girl C		a*		
48	Boy A	a, b			
	Boy C				a*
	Boy G		a, d	c	b
	Girl D	†a, b			
52	Boy A	b	c, d		a
	Boy C	‡a, b, c		d, e	
	Boy J	b, c,§ d		e	a, f
	Girl B	a, b			
	Girl D				a
	Girl E	//a*, b*, c*			

†Preceded by three successes in position B achieved by pushing on the short arm (*a*) with one error, (*b*) and (*c*) with no errors. Two failures in A after B (see Table 1) seemed due to lack of interest.

‡After demonstration.

§Between successes *c* and *d* there was one failure due to turning away after correctly pushing on the short arm.

//Preceded by failure in A and success in B.

SUPPLEMENT TO TABLE 5

NATURE OF "ERRORS" IN SUCCESSFUL TRIALS LISTED IN TABLE 5

Letters corresponding to those in Table 5 indicate the trials in which the errors occurred, dots indicate the frequency of the error

Nature of error	44 weeks	48 weeks	52 weeks
Rotate Clockwise	Boy G b Boy J b d Girl B a. .	Boy C a Boy G a b . d	Boy A a c d Boy C d Boy J a. .. f
Tug directly along lever	Boy J a b c d . Girl B e	Boy C a Boy G b	Boy A a Boy C e Boy J e . f Girl D a
Slide too close to grill and table	Girl C a	Boy C a Boy G c.	
Reach toward Examiner	Boy J a.		
Scratch at screw	Boy J c		
Regard Examiner		Boy C a	Boy J a (vocalizes)
Fret		Boy C a	
Creep to rear of crib		Boy G b	
Pry at end of lever		Boy G c	Boy J a f.
Pull self to standing			Boy J a

was apparently due to emotional maladjustment. At 52 weeks Girl B and Boy J both give signs of prompt mastery of the situation. Boy C shows three errorless successes after the Examiner's demonstration. Boy A is not quite so good as at 48 weeks, but perhaps his single brief clockwise pull in trials *b* and *c* should not disqualify him. Girl D's performance was marked by lack of sufficient interest in the bell: on her second trial when it came in reach she made no attempt to secure it, apparently did not see it. Girl E's series of errorless successes was achieved by the method of rotating the long arm. On trial *c* she made the shift from the short arm to the long one which we noted above (p. 366) as suggesting observation of the function of the pivot.

Just as Figure 4 revealed more than Figure 3 the development that preceded 40 weeks, Table 5 and Table 6 indicate significant

TABLE 6

Percentage of Infants Who Showed a Series of Two or More Consecutive Successes in Position A, Marked by Not More Than One Error

Age in weeks	Number of infants examined	Percentage showing successes as indicated above
44	12	8
48	11	18
52	12	42

developments after 44 weeks which are obscured in Figure 3. Much more striking than the increase in the percentage of successful infants in position A is the increase in the percentage of infants who showed a series of two or more consecutive successes marked by not more than one error (Table 6). Here the sharp rise occurs between 44 and 52 weeks.

Shall we conclude that between 40 and 44 weeks the great increase is in motor capacities and that between 44 and 52 weeks the great advance is in perception? Perhaps this is part of the truth. It is likely, however, that a simpler form of perception is developing earlier, perhaps what we have called the response to the visual structure of the situation. At a later age, conversely, it is likely that a continuing increase in stability and accuracy of motor control facilitates perception and is accompanied by increase in stability and completeness of understanding.

In this development it is likely that maturation plays a fundamental rôle, but that learning also has a part. Advancing perceptive capacity could be considered an increasing capacity to *learn from observing* a successful performance in the examination situation Furthermore, it seems reasonable to suppose that the infant's activities in daily life may give some opportunity to observe pivotal relationships more or less analogous to those involved in our special problems and may also have an influence on motor development. "Function enters into growth" (5), and growth makes possible a more advanced type of functioning

Motivation, Emotional Adjustment, and Individual Reactions to Thwarting In addition to development, with its motor and perceptual aspects and its maturational substratum, another factor that influences success is undoubtedly motivation. Success and freedom from errors are measures of motivation as well as of motor and perceptive capacity Table 1 shows that successful trials were frequently followed by failures This might be an indication that success was more accidental than insightful At 48 and 52 weeks, however, all the cases where this occurred in position A can be ascribed to decline of interest in the lure. At 44 weeks this is true of one case out of three. The influence of decline in motivation is more subtly shown in Table 5. In all the four instances where four or more successful trials were given and where the second trial was errorless, the number of errors increased after the second, third, or fourth trial.

The probability that success is influenced by emotional adjustment to the examination situation has already been mentioned in connection with the failures of Girl B and Boy J at 48 weeks after their successes at 44 weeks (p. 369) Boy D's failure to repeat his successes of 36 weeks in any later examination might be ascribed to his characteristic irritability, coupled with a strong locomotor drive.

The personality differences revealed in the reactions to thwarting were an interesting incidental aspect of the behavior which we shall mention only briefly here Besides crying, there were persistence in a given activity or in varied activity directed toward the goal, simple "reductive devices" such as scratching the platform, "compensations" such as turning to locomotor activities, and at 48 and 52 weeks a

few instances of extending the hand to the Examiner and tugging at her smock.

The Value of Demonstration. Figure 3 shows that demonstration by the Examiner added nothing to the few successes that preceded 44 weeks Table 2 shows in addition that through the age of 40 weeks fewer infants moved the lever after demonstration than before. Apparently demonstration is of no avail unless the motor capacity is adequate to the problem When the demonstration was merely an addition to a series of thwartings, the most frequent form of response was fretting, crying, or other vocal protest

From 44 to 52 weeks inclusive, more results from the demonstration are apparent Yet even here demonstration is responsible for only 23 per cent of the successes.

TABLE 7

PERCENTAGE OF THE PREVIOUSLY UNSUCCESSFUL WHO SUCCEEDED AFTER DEMONSTRATION AT 44, 48, AND 52 WEEKS

Age in weeks	Number of infants examined	Percentage of infants who succeeded in A or B before demonstration	Percentage of the previously unsuccessful who succeeded after demonstration
44	12	50	33
48	11	64	25
52	12	58	60

Table 7 presents the data in an aspect which suggests that at 52 weeks demonstration is considerably more profitable than at any preceding age

Does the value of demonstration lie in facilitating insight, or in increasing motivation, or in both?

There are six cases of success following demonstration (see Table 1). The two at 44 weeks seemed rather clearly to be due to increased motivation rather than to insight The one at 48 weeks seemed due to increased motivation which came from a change of lure rather than from the demonstration. The same explanation seems to cover the case of Boy E at 52 weeks Girl A's behavior at 52 weeks suggested a fleeting bit of insight, unstable partly because of decline in motivation or because of fatigue Boy C at 52 weeks furnished the only instance in which a series of successes

that might be called insightful followed the demonstration, and here there was apparently at the same time an increase in motivation In general, when insight is inferable, through the ages covered by these experiments, it seems to come from the infant's observing the results of his own behavior rather than from his observing the Examiner's manipulation of the lever.

SUMMARY

1. Fifteen selected infants were observed at intervals of 4 weeks from the age of 28 weeks to one year in a situation wherein a distant toy could be brought in reach by rotating a horizontal lever in a counterclockwise direction. The lever was presented both in the median plane (position A) and obliquely (position B) In case of failure, demonstration of rotation was given by the Examiner.

2. Between 40 and 44 weeks the percentage of infants who succeeded at least once in rotating the lever to bring the toy in reach increased from 20 per cent to 67 per cent. By 52 weeks it was 83 per cent

3. Between 44 and 52 weeks the percentage who were successful in position A in at least two consecutive trials with not more than one erroneous move per trial increased from 8 per cent to 42 per cent In none of these cases was there more than one trial preceding these relatively errorless trials. This increase is taken to mean an increase in the number whose successes were accompanied by appropriate and relatively stable insight (observation of the means to success).

4. When successes were repeated, the records in a number of cases make it clear that mastery did not consist in performing always the same motor reaction "Appropriate insight" apparently meant the development of a more or less variable means of attaining a goal.

5. Several types of perceptive attitude (or degrees of insight) could be inferred from the behavior. Response determined by the visual structure of the situation came earlier than appropriate response determined by the physical structure The latter was inferred to develop out of the infant's observation of the results of his own behavior.

6. Successes were apparently dependent on age (motor and perceptual development), on motivation, and on emotional adjustment

7 Demonstration by the Examiner contributed little if any-

thing to insight Beginning at 44 weeks it seemed to have some value in adding to the motivation

8 The results suggest that, if such problems as these were to be used as tests of development, the part played by motivation, by emotional adjustment, and by socially conditioned habits of meeting difficulties should also be taken into consideration.

References

1. Adams, D K Experimental studies of adaptive behavior in cats *Comp Psychol Monog*, 1929, 6, No 1. Pp 168
2. Brainard, P P The mentality of a child compared with that of apes. *J Genet Psychol*, 1930, 37, 268-293
3. Drescher, K, & Trendelenburg, W Weiterer Beitrag zur Intelligenzprufung an Affen (einschiesslich Anthropoiden). *Zsch f vergl Physiol*, 1927, 5, 613-642
4. Gesell, A Infancy and human growth New York: Macmillan, 1928 Pp xvii+418
5. Gesell, A, & Thompson, H Learning and growth in identical infant twins an experimental study by the method of co-twin control *Genet Psychol Monog*, 1929, 6, 1-124.
6. Guillaume, P, & Meyerson, I Quelques recherches sur l'intelligence des singes Communication préliminaire *J de psychol*, 1930, 27, 92-97
7. ——— Recherches sur l'usage de l'instrument chez les singes II L'intermédiare lié à l'objet *J de psychol*, 1931, 28, 481-555
8. Halverson, H M An experimental study of prehension in infants by means of systematic cinema records *Genet Psychol. Monog*, 1931, 10, 109-286
9. Hobhouse, L T Mind in evolution (2nd ed) London Macmillan, 1915 Pp xix+469
10. Kluver, H Behavior mechanisms in monkeys Chicago Univ Chicago Press, 1933 Pp xvii+387.
11. Kohler, W. The mentality of apes (Trans by E Winter) (2nd ed) New York Harcourt, Brace, London: Kegan Paul, 1927 Pp viii+336
12. Lindemann, E Untersuchungen uber primitive Intelligenzleistungen hochgradig Schwachsinniger und ihr Verhaltnis zu den Leistungen von Anthropoiden. *Zsch f d. ges Neur u Psychiat*, 1926, 104, 529-570
13. Neumann, H, & Trendelenburg, W Ein Beitrag zur Intelligenzprufung niederer Affen *Zsch f vergl Physiol*, 1926, 4, 142-200
14. Richardson, H M The growth of adaptive behavior in infants: an experimental study at seven age levels *Genet Psychol Monog.*, 1932, 12, 195-359
15. Shepherd, W T Some mental processes of the rhesus monkey *Psychol Monog*, 1910, 12, No 5 Pp 62

16 ——— Tests on adaptive intelligence in dogs and cats as compared with adaptive intelligence in rhesus monkeys *Amer J Psychol*, 1915, 26, 211-216.

17. THORNDIKE, E L Animal intelligence New York: Macmillan, 1911. Pp. viii+297

18 TOLMAN, E. C Habit formation and higher mental processes in animals. *Psychol. Bull*, 1928, 25, 24-53

19 YERKES, R M The mind of a gorilla *Genet Psychol Monog.*, 1927, 2, 1-193

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LE COMPORTEMENT D'ADAPTATAION DES PETITS ENFANTS DANS L'UTILISATION DU LEVIER COMME OUTIL

(Resumé)

On a observé quinze petits enfants choisis à intervalles de 4 semaines de l'âge de 28 jusqu'à l'âge de 52 semaines dans une situation où ils ont pu atteindre un jouet lointain en faisant tourner un levier horizontal On a présenté le levier et dans la surface plane médiane (position A) et obliquement (position B). Dans le cas d'un essai non reussi, l'Examinateur a donné une démonstration de la rotation

Entre l'âge de 40 et 44 semaines le pourcentage des enfants qui ont réussi du moins une fois à faire tourner le levier pour atteindre le jouet s'est accru de 20% à 67% A 52 semaines il a été de 83%

On a pu déduire plusieurs degres de connaissance approfondie du comportement. Le succes dans la position A dans au moins deux épreuves consécutives, avec non plus d'un mouvement erroné à chaque épreuve, et avec non plus qu'une épreuve précédant ces épreuves, a éte considére une indication d'une connaissance appropriee et relativement stable Huit pour cent des enfants a satisfait ce critère à 44 semaines; 42 pour cent à 52 semaines Des succès répétés n'ont pas compris nécessairement la répétition des mouvements spécifiques

Il paraît que les succès ont dépendu de l'âge (du développement moteur et perceptible), des mobiles, et de l'adaptation émotive Il paraît que la démonstration par l'Examinateur a contribué peu ou rien à la connaissance. A partir de 44 semaines elle a semblé avoir quelque valeur comme addition aux mobiles

RICHARDSON

DAS ANPASSUNGSVERHALTEN KLEINER KINDER BEI DER ANWENDUNG DES HEBELS ALS WERKZEUG

(Referat)

Funfzehn ausgewahlte Kinder wurden in Abstanden von 4 Wochen (zwischen 28 bis 52 Wochen) in einer Situation beobachtet, wo ein entferntes Spielzeug durch das Drehen eines wagerechten Hebels herangezogen werden konnte Der Hebel wurde sowohl in der Mittelebene (Stellung A) als auch schräg (Stellung B) gestellt Beim Versagen wurde das Drehen vom VI dem Kinde vorgefuhrt.

Zwischen 40 und 44 Wochen wurde der Prozentsatz der Kinder, denen es mindestens einmal gelang, den Hebel zu drehen und das Spielzeug heranzuziehen, von 20 bis auf 67 Prozent erhoht. Bei 52 Wochen war er 83 Prozent.

Mehrere Grade von Einsicht konnten aus dem Verhalten geschlossen werden. Ein Erfolg in Stellung A in mindestens zwei aufeinanderfolgenden Versuche mit nicht mehr als einer Fehlbewegung pro Versuch und mit nicht mehr als einem Versuch, der diesen voranging, wurde als Zeichen einer passenden und verhaltnismassig stabilen Einsicht angesehen. Acht Prozent der Kinder erfullte dieses Kennzeichen zu 44 Wochen, 42 Prozent zu 52 Wochen. Wiederholte Erfolge bedeuteten nicht immer eine Wiederholung bestimmter Bewegungen.

Erfolge waren wahrscheinlich vom Alter (motorischer Entwicklung und Entwicklung der Wahrnehmung), von der Motivierung, und von der Gemutsanpassung abhangig. Das Vorfuhren vom VI trug wahrscheinlich wenig der Einsicht bei. Von 44 Wochen an schien es von Bedeutung, die Motivierung zu erhohen.

RICHARDSON

IS THE WALL-SEEKING TENDENCY IN THE WHITE RAT AN INSTINCT?*

From the Department of Psychology of Ohio University

JAMES R. PATRICK AND ROBERT M. LAUGHLIN

ORIENTATION[1]

For some time now the senior writer has been demonstrating to general psychology classes under the topic of "instinct" the wall-seeking tendency of the white rat The demonstration consists of putting a young rat (old rat could just as well be used) into the narrow entrance of an *open-alley* maze (see Figure 2, ground floor of maze) placed on a table in the laboratory and then to encourage the rat forward until he reaches the part of the maze that opens out, the rat is allowed then to wander about over the maze for a given period of time, usually about two minutes. Rats will almost invariably run along the right (left) wall of the maze until they reach the edge then reverse and come back along the same route traversed while going forward Only now and then will they even attempt to go out in the open area near the center of the maze The phenomenon appears so consistently in rats that have had no experience with mazes that it is wont to be termed instinctive or native behavior The senior writer, however, has long since suspected that the behavior observed is not instinctive but partially at least, if not wholly, learned. The hypothesis concerning the wall-seeking tendency of the white rat has arisen in his thinking something like this. Could not the early nest experiences, in which contacts both with mates and mother, as well as with nest materials, along with temperature conditions, favor the establishment of early reaction tendencies toward objects and things *per se*? Again, usually the pregnant mother rat, whether wild or domesticated, builds a nest of some sort before giving birth to her young. Thus, the young rat is born into shadowy conditions made so by the nest itself

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[1]The writers are refraining from summarizing here the literature on the topic "instincts"

That is, when the rat's eyes are first opened he encounters not bright open spaces but shadowy conditions such as walls usually afford. Now, if this guess is true, rats that are allowed to grow up from birth not in ordinary nesting conditions but on an open floor area free from shadows, made by excelsior or other nest materials, would tend to explore open areas as well as to run along beside walls such as the open-alley maze affords With these things in mind the experiments subsequently reported were carried out.

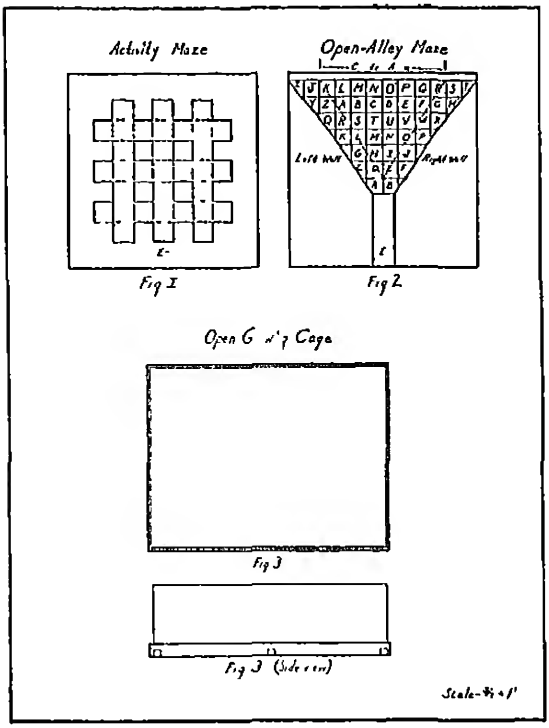
Ideal experimental conditions would require accurate temperature control; air-movement control; contact control; even feeding the young artificially instead of allowing them to nurse the mother, and, further, the segregation of individuals in the litter, control of brightness effects after eyes are open, auditory and perhaps other factors would have to be checked It will readily be seen that a full control of all factors mentioned above would necessitate removing the young animals very far from their ordinary life conditions Again, to say just what is responsible for the wall-seeking tendency in the white rat each of the above-mentioned factors should be isolated and measured while all other variables are controlled. This is an ambitious task What we have attempted to do is to keep the animals in as nearly ordinary life conditions as possible and at the same time control some factors and then see if the rat will not leave the walls in his exploring. If he does run into the open more freely after having grown up in the kind of experimental living conditions that we offer him, we can at least say that the rat has no specific inherited behavior pattern which makes him cleave always to a wall while in a maze situation like the one used in this set-up

Animals and Technique

Young rats, along with their mother, were placed in an *open growing-cage* at seven days old and allowed to grow up in this cage until five weeks old. The growing-cage floor was made of matched pine flooring 4 inches in width The boards were pulled together and nailed so that the floor was smooth (See ground floor and side of open growing-cage in Figure 3) The walls of the cage were made of glass of window-pane quality and thickness which was set up on edge in grooves made for that purpose in the floor The growing-cage walls were 20 inches high. The box was placed on a stand in a position about 4 feet from, but facing, a win-

dow in the laboratory, and a little nearer the right corner of the room than the left At the right end of the cage (as the experimenters faced the cage and window) the human eye could detect a slight shadow from the room wall whenever the sun reached a given point and shone through the laboratory window With this exception, the floor area of the growing-cage was uniformly illuminated as far as the human eye goes. Try as we might, we could not get this small area of the growing-cage free of this shadow unless we used artificial light. This we did not wish to do since we were allowing a control group of young rats to grow up in their nests under ordinary daylight and darkness conditions. The mother rats were allowed to stay with their litters until the young were old enough to eat for themselves. Only one mother rat and her litter were grown in the cage at a time. Really four litters in all were grown in the growing-cage. However, data are reported from two litters. One of the two litters reported had six rats, and the other had five This latter group was later reduced to four as one of the rats suffered an injured leg and his record is not included. Two litters were sacrificed from an experimental standpoint in perfecting a technique. We started using wire screen for walls but found it unsatisfactory. We had to handle carefully the mothers and their litters in order to keep some mothers from destroying their young It was for this reason that we allowed the mothers to remain in the ordinary cage for seven days after their litters were born. Some mothers seemed to "resent" being moved to the growing-cage along with their young, even after the young were a week old. We tried putting a pregnant female rat into the growing-cage some days before parturition but she seemed not to do so well and spent much time gnawing and scratching the floor, apparently attempting to build herself a nest

Simultaneously with the growing of each of the experimental litters in the growing-cage, we had litters growing in ordinary nesting conditions The nests consist of wire cages with pans in the bottom containing excelsior for a bed Young rats usually stay burrowed in the nesting material for the first few days of life As soon as they are mature enough to locomote they come forth and return to their bed at "will." Four litters constitute the two groups in this experiment. Two litters consisting of ten rats make up the experimental group which was grown in the open growing-cage Ten rats taken from two litters which were grown under ordinary nesting



conditions constitute the control group The groups hereafter will be spoken of as *experimental* and *control*

The maze patterns used are shown in Figures 1 and 2 Each maze floor is marked off with a pencil into squares and the number of crossings made over each square during the tests constitutes a rat's record. In the open-alley maze the walls (schematically shown in Figure 2) are 5 *inches in height* The *activity maze* (see Figure 1) was used as a check only after it was observed that the so-called "exploratory drive" or "activity level" of rats which were grown in the open growing-cage, while in the open-alley maze, apparently far exceeded that of the rats grown in the ordinary nest cages. All rats were fed one and one half (1½) hours before the test runs were given All rats, both experimental and control groups, were put into the open-alley maze at the age of five weeks Each rat was put

into the maze separately and allowed to remain in the maze for two minutes. Two litters, one experimental and one control, were tested at a time. In one series the animals from each litter (experimental and control) were put into the maze in an alternate fashion. That is, one rat from the experimental group was followed by one from the control. The other two litters, one from each group respectively, were not alternated. That is, one rat at a time was put in until the whole experimental-group litter were used. These were followed by all rats (separately, of course) from the control-group litter. A bar was inserted at the end of the entrance alley in the open-alley maze to keep the animals out of the narrow channel. This forced them to remain in the wide open areas of the maze. Tracings of each animal were recorded on mimeographed sheets upon which were reproduced drawings of the maze pattern. In order to observe uniformity in scoring the maze pattern, record sheets were ruled off (see Figure 2) so that one could follow the rat's activity along the *right wall*, along the *left wall*, and in the *center area*.

As was mentioned above, the increased "exploratory drive" on the part of the rats grown in the open growing-cage prompted us to follow up the open-alley-maze tests with the activity-maze tests. Therefore, each rat, as soon as all rats of given litters were put into the alley maze, was put immediately into the active maze for a period of two minutes and the number of squares covered recorded.

By very careful control of the temperature and feeding the rats in the open growing-cage seemed to thrive and to grow as rapidly as the ones that grew up in the nests. Hence all animals whose data are here reported seemed to be in good health at the time that these tests were made.

Results and Discussion

In order to see if the mean[2] number of squares crossed in the open-alley maze by the two groups, experimental and control, differed, Table 1 was made. The experimental group shows a mean of 61.30 squares crossed, while the control shows only a mean of 38.50 squares. The very noticeable difference in the "exploratory drive" on the part of the experimental groups led us to check this tendency in the activity maze. The σ differences are large in all

[2]Only group averages with σ deviations are given here, individual scores of all rats are on file in the Psychology Laboratory of Ohio University.

TABLE 1

DIFFERENCE BETWEEN GROUP AVERAGES OF ALL SQUARES CROSSED IN OPEN-ALLEY MAZE

Experimental group N = 10			Control group N = 10			Difference between		
Mean	σ	σ_M	Mean	σ	σ_M	M_1 and M_2	σ_{diff}	$\frac{Diff}{\sigma_{diff}}$
61.30	22.51	7.11	38.50	16.43	5.19	22.80	8.81	2.58

TABLE 2

DIFFERENCE BETWEEN GROUP AVERAGES OF SQUARES CROSSED ALONG RIGHT WALL, ALONG LEFT WALL, IN THE CENTER AREA, OPEN-ALLEY MAZE

	Experimental group N = 10			Control group N = 10			Difference between		
	Mean	σ	σ_M	Mean	σ	σ_M	M_1 and M_2	σ_{diff}	$\frac{Diff}{\sigma_{diff}}$
Right wall	27.0	11.15	3.52	17.4	13.29	4.20	9.6	5.48	1.75
Left wall	17.2	7.11	2.24	14.5	8.02	2.53	2.7	3.39	0.79
Center area	17.1	9.54	3.01	6.6	5.95	1.88	10.5	3.55	2.96

cases, but this is to be expected from the size of the groups. While the difference between the means divided by the standard error or the difference does not reach the conventional criterion of reliability (3 00), certainly the figure obtained (2 58) shows a much greater than chance tendency on the part of rats grown up in the open growing-cage to explore an open-alley maze more freely than rats which have grown up under ordinary nest conditions

The pertinent point, however, with respect to the present problem is to be found in Table 2. This table shows the mean number of squares crossed along the *right wall*, along the *left wall*, and in the *center area* of the open-alley maze. There is no appreciable difference between the two groups exploring along the left wall The means are about the same, 17.2 and 14 5, respectively The exploration along the right wall on the part of the two groups is different The experimental group shows a mean of 27 9, while the control group has a mean of only 17.4. The last column of Table 2 for these means shows a reliability difference of only 1 75, still this figure looks like a tendency on the part of the experimental group to explore along the right wall more freely than the control group. Since the maze was placed in the very position of the growing-cage when the test runs were given (it has already been mentioned that the right side of the growing-cage floor had a shadow at times upon it), and since daily observation showed the rats seemed to huddle during sleep more frequently at that end of the cage while growing up, it may be that they tended to establish a position or an orientation habit in that direction. This point is really against our hypothesis By our hypothesis we would expect rats grown up in nests and accustomed to shadowy conditions (control groups here) to seek that side of the maze more frequently The only definite thing we can say is that the difference between the two groups is not a reliable one. Exploration in the center area of the maze is really the crucial test in this experimental situation. After all, whether our hypothesis is right or wrong the fact remains that the rats which were grown up in the open growing-cage ventured forth from the walls of the alley maze into the open area enough times just about to meet the statistical conventional reliability criterion of 3. The reliability factor is 2 96. The chances are over 99 out of 100 that the difference is a true one. From Table 2 it seems, we may say, that rats which have grown up from very early infancy in an open growing-cage will tend

not to seek walls only of an alley maze but will venture out into the open area or the center of the maze also; but that rats grown up *under ordinary nesting conditions will venture forth into open spaces* to only a very slight degree The above statements are supported by the fact that the means of the two groups with respect to the number of squares crossed in the center area are 17.1 and 6.6, respectively. Assuming that our samples are representative, the difference is a reliable one Table 2 again shows the "activity level" or the "exploratory drive" to be greater for the experimental group than for the control in the different areas of the alley maze. This seems to indicate that animals which have had a less circumscribed early environment and which perhaps have had the "feelings" of freer muscular action in romping tend to do more of that sort of thing than rats which have not heretofore had that opportunity.

Table 3 further confirms the results of increased "exploratory drive" on the part of rats grown up in a relatively large open cage when compared with rats grown up in ordinary nesting conditions The difference between the means of these two groups is a reliable one

Since the experimental group of rats tends to show a reliable tendency to "explore"[3] more than the control group, some will say, "Does not the very fact that they explore more give a greater chance probability for the actual exploration to take place also in the center of the maze?" In other words, is the greater tendency of the experimental group to explore into the center maze a function of the increased exploratory tendency resulting in an increased activity level? The writers' answer to this question lies in the results summarized in Tables 1, 2, and 3 The experimental group of rats explores more *in all parts of the open-alley maze* as is shown in Table 1 But while the experimental group is exploring more, at the same time Table 2 shows a much greater relative increased tendency to leave walls and go out into the open than just general increased activity could account for The experimental group explores more, but it also explores more in a given area. Compare the statistical reliabilities between the means of the two groups with respect

[3]This increased exploratory tendency on the part of the experimental group may be due to transfer Certainly the open growing-cage has a "spaciousness" in common with the mazes which the ordinary nest does not have to the same degree

TABLE 3

DIFFERENCE BETWEEN GROUP AVERAGES IN NUMBER OF SQUARES CROSSED IN ACTIVITY MAZE

Experimental group N = 10			Control group N = 10			Difference between		
Mean	σ	σ_M	Mean	σ	σ_M	M_1 and M_2	σ_{diff}	$\frac{\text{Diff}}{\sigma_{diff}}$
53.20	17.05	5.39	27.50	13.25	4.19	25.70	7.03	3.54

to the three areas of the maze (right wall, left wall, and center area) The reliability figure for the center area is relatively much larger than the figure for the right wall and left wall It seems fair to say that a part of this whole increased exploratory tendency on the part of the experimental group when compared with the control group is due to the fact that they increase their range of activity by entering the center area of the maze, while animals that have grown up under more restricted conditions, such as ordinary nest life affords, are more inhibited about exploring in open areas. Different early life experiences in the white rat, it seems, account, partially at least, for the *wall-seeking or lack of wall-seeking* tendency on the part of the white rat under the present experimental conditions If this is true then we cannot say that the *wall-seeking tendency* is wholly instinctive

Instead of being a more or less definite *specie patterned reaction* ("instincts") determined chiefly by *structure, maturation,* and *function,* as many reaction patterns in organisms are, may we not say that early environmental conditions are largely responsible for the rather definite behavior pattern on the part of rats reared in nests of laboratories or in the wild (if it is true likewise of wild animals) to seek the cover of walls in exploring? Our observations bear out the results that animals which have grown up in ordinary nest cages seem more cautious and appear more timid as they crawl and run about than do animals which have grown gradually accustomed to brightness and to open areas and have been allowed a freer activity in exploring, such as the conditions afforded our experimental group. It is our opinion that brightness and perhaps contact experiences, as well as fear of the new, coupled with habits of adjustment to walls and obstacles, are chiefly responsible for the wall-seeking tendency of the white rat. In case of extreme brightness effects, however, one would have to go into the chemistry of the eye for an explanation of the avoidance of it.

Summary

1 Rats that have grown up in an open growing-cage such as the one described in this experiment tend to run out from walls into open areas of an open-alley maze more readily than rats grown in ordinary cage nests. The difference between averages of distance cov-

ered by the experimental and control groups seems to be a true difference, provided our samples are representative.

2 Rats that have grown up in an open growing-cage manifest a statistically reliable greater tendency to exhibit the so-called "exploratory drive" than rats which have grown up in the ordinary nesting cage.

3 Perhaps the factors of degrees of brightness and early habits coupled with timidity about experiencing open spaces as well as early conditioning to contacts, temperature, etc., are responsible to a great degree for the rather definite wall-seeking tendency of the white rat grown up under ordinary nest conditions If this is true, the tendency is not a specific instinct in the orthodox sense of the term.

LA TENDANCE À CHERCHER UN MUR CHEZ LE RAT BLANC EST-ELLE UN INSTINCT?

(Résumé)

Des observations repetées montrent que les rats blancs tendent à se diriger le long des murs d'un labyrinthe à parcours ouverts (labyrinthe où deux murs renferment un parcours étroit qui mène à une plus large surface ouverte de la forme d'un eventail) plutôt qu'à chercher la surface ouverte du labyrinthe Ce comportement paraît si constamment chez les rats qui n'ont eu aucune experience dans le labyrinthe qu'il paraît être une forme innée du comportement On a posé la question "Les premières conditions de vie des jeunes rats, y compris tels facteurs que les nids obscurs, les contacts avec la mère, les autres rats et les materiaux du nid, et le manque de l'adaptation graduelle aux surfaces ouvertes, ne pourraient-elles expliquer le tendance à chercher les murs?" Pour tester cette hypothèse on a elevé des portées de jeunes rats dans une cage ouverte sans matériaux du nid, ayant des murs de verre transparent. On a élevé d'autres portées dans les conditions ordinaires d'une cage contenant un nid Les rats élevés dans les deux groupes de conditions ont été testes à l'âge de 5 semaines dans les labyrinthes à parcours ouverts et d'Activité Les résultats montrent que les rats élevés dans les conditions de la cage ouverte tendent à explorer les surfaces ouvertes beaucoup plus vite que les rats elevés dans les conditions ordinaires d'une cage contenant un nid. L'"Impulsion Exploratrice" est constamment plus grande aussi chez les rats élevés dans la cage ouverte La tendance à chercher les murs semble être influencée par les premieres conditions de vie

PATRICK ET LAUGHLIN

IST DIE WANDSUCHENDE TENDENZ BEI DER WEISSEN RATTE EIN INSTINKT?

(Referat)

Wiederholte Beobachtungen haben gezeigt, dass weisse Ratten die Wände eines offenen Labyrinths (ein Labyrinth, in dem zwei Wände einen engen Gang einschliessen, der zu einer weiteren fächerförmigen, offenen Fläche führt) lieber erforschen als die offene Fläche. Diese Verhaltungsweise erscheint so regelmässig bei Ratten, welche keine Erfahrung mit Labyrinthen gehabt haben, dass es eine angeborene Verhaltungsgestalt zu sein scheint. Die Frage wurde aufgeworden, ob die frühen Lebensverhältnisse der jungen Ratten, einschliesslich solcher Faktoren wie schattige Neste, Berührungen mit der Mutter, Nestgefährten und Materialien, und das Fehlen einer allmählichen Anpassung an offene Flächen, die wandsuchende Tendenz erklären würden. Um diese Hypothese zu erproben, liess man Würfe von jungen Ratten in einem offenen Käfig mit keinen Nestmaterialien und mit Wänden von durchsichtigem Glas aufwachsen. Andere Würfe wurden in gewöhnlichen Nestkäfigen aufwachsen lassen. Die Ratten, welche unter den beiden Umständen wuchsen, als sie fünf Wochen alt waren, wurden in dem offenen Labyrinth und in dem Tätigkeitslabyrinth geprüft. Die Ergebnisse zeigen, dass die Ratten, welche in dem offenen Käfig aufgewachsen sind, offene Flächen lieber erforschen als Ratten, welche unter gewöhnlichen Umständen aufgewachsen sind. Der "Erforschungstrieb" ist auch grösser bei den Ratten vom offenen Käfig. Die wandsuchende Tendenz scheint durch die frühen Lebensverhältnisse beeinflusst zu sein.

PATRICK UND LAUGHLIN

THE EFFECT OF PRACTICE ON THE DELAYED REACTION IN THE RHESUS MONKEY*[1]

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HISTORICAL INTRODUCTION

Nature is replete with situations in which animals, in their natural habitat, are reacting to stimuli which apparently are not present at the moment the response is made The tiger stalks its prey in the dense undergrowth of the jungle, while the domestic animals wander home at feeding time The grey squirrel buries nuts near its home tree, only to return several days later to go directly to the spot where the food was buried and recover it The hungry robin reacts to the place where the worm was last seen or heard. Similarly, the cat silently waits for the mouse to appear at an open hole, subsequently springing upon the correct hole after the mouse has appeared and vanished. Surely these forms of behavior, barring possible olfactory stimulation, fit equally well into the pattern of delayed reaction Nor is man by any means excluded from participating in such behavior. In everyday life man is continuously reacting to stimuli which are said to be beyond his perceptual range. In fact, life is a constant stream or ever-changing mosaic of such activities, many of which are capable of artificial control, isolation, variation, and repetition

Such behavior has frequently come to the attention of the psychologist and psychobiologist When the question is raised as to just what is happening when one of these reactions occurs, the answer is usually immediately forthcoming and apparently extremely simple. "Memory." But is this not a platitude, and to the more

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[1]This report covers one major topic in a project on motivation and intelligence in the rhesus monkey, supported by the Council for Research in the Social Sciences of Columbia University.

[2]This experiment was planned and carried out in cooperation, the junior author securing and tabulating the data, both authors being responsible for the report in its present form.

ardent critic a mere name for the particular behavior under consideration? Thus several years ago the more experimentally inclined psychologists attempted to bring such phenomena into the laboratory and study them under controlled conditions. The first studies were "memory" and "association" experiments on human beings Later, the comparative approach was attempted, and this gave rise to the "delayed reaction" experiments In fact, there was the conviction that the problem of memory, as all other psychological problems, might best first be studied in infrahuman organisms, where the experimental situation could be better controlled and where the behavior would appear in its most elementary form.

Thus the delayed-reaction experiment was devised as a means of studying memorial phenomena in infrahuman organisms, although it was soon applied to the human as well Associations are set up between some specific stimulus, such as food, light, sound, etc, and certain movements or indicators of response on the part of the animal which lead to some incentive When this preliminary association is established between stimulus and response, a period of delay is introduced between the cessation of the stimulus and the moment of reaction. This interval is subsequently increased until the "maximum" period of delay is obtained

Thus the above-mentioned cat-mouse situation would approach the laboratory experiment if, as Hunter (21) has suggested, there were three holes that differed only in their several directions from the cat, and if in the past the mouse had appeared an equal number of times at each of the three holes This would require the cat to select between the holes on the sole basis of the immediately previous presence of the mouse, if a correct response were to occur. If the cat were then to be delayed for a period after the mouse had disappeared, this naive set-up would closely approximate the laboratory experiment on delayed reaction.

We have previously stated that a delayed response is one in which the "determining" stimulus is absent at the moment of response In any such study, two important questions arise, and each has been treated by numerous investigators The first of these is the question as to how long after the determining stimulus has disappeared the animal can delay and still react correctly The second question is concerned with the animal's method of solving the problem, i.e., the exact mechanism which is used to insure correct

response after the period of delay. Hunter (21), Tinklepaugh (42), and others have referred to this mechanism as the "representative factor" and have attempted to determine whether it is "motor," "sensory," or "ideational." Evidence concerning this question may be had from observing the animal in the experimental situation, noting all cues which are possibly functional, and by artificially varying and otherwise controlling the situation itself.

Numerous experiments have been performed on organisms of different species, ranging from the chicken and albino rat to the human adult. The maximum period of delay for different species differs widely from experiment to experiment, and one is puzzled to know which, if any, is correct. In fact, there is almost as much variation in results among experiments on a given species as between the species themselves. The data from these studies seem to show that the delay period is bridged either by the maintenance of overt bodily attitudes which form the basis for reaction after delay, or else by means of some intra-organic cue which is either maintained during the delay or reinstated shortly thereafter. The earlier studies indicated that rats, cats, and dogs could react correctly after delay only when the first method was used, whereas raccoons, monkeys, apes, and humans were able to respond correctly when such bodily orientation was not maintained and consequently must have been reacting on the basis of some intra-organic cue. Later experiments, however, show conclusively that dogs, cats, and even rats can react correctly after delay without such overt bodily orientation.

In view of the seeming chaos and disagreement in the field of delayed reaction, especially in the matters of maximal delay and theoretical interpretation of results, it was decided to attempt to determine what factors might be operating to cause such wide discrepancies. The writers were of the opinion that perhaps such wide differences in method and maximum period of delay were due to the particular experimental situation and procedure used in the various studies. In brief, it was surmised that the animal could literally learn to delay for intervals significantly longer than those obtained before practice. Thus it was decided to devise a rather difficult experimental situation and, after the animal had unquestionably learned to make the correct immediate response, to measure the accuracy of the animal's delayed responses before and after practice. The experiment is thus a study of the effect of practice

on the delayed reaction, although the writers are of the opinion that learning and memory, those two fundamental categories of behavior, not only have much in common, but are basically the same process viewed from different angles. Perhaps the problem of delayed reaction resolves itself into a study of the ability of the animal to learn to respond to a cue other than the ones which the investigator has experimentally eliminated.

Comparison of Methods

The first attempt to study the delayed response in a controlled laboratory situation was made at the University of Chicago under the direction of Harvey A Carr. The earliest experimentation was begun by a graduate student, W R Hough, whose work was carried further the following year by H B. Reed. These studies were never completed but served as a preliminary to the later investigation of Walter S Hunter (21), which was carried on in the same laboratory from October, 1910 to April, 1912 Since then numerous experiments have been conducted on the delayed reaction in laboratories both throughout the United States and abroad

Hunter (25) has pointed out the essential features which any apparatus and procedure must embody in order to study the delayed response These are as follows. (1) It must be adapted to the size of the animal or subject and its mode of response. (2) It must provide a means for presenting a stimulus in one of several places. (3) These stimulus places must be equally accessible to the response (4) The stimulus and method should be such as to present no differential cues to the subject during the interval of delay. Attention might here be called to the pronounced similarity between the delayed-reaction and multiple-choice experiments. In the former situation, the number of reaction alternatives is held constant and the period of delay before response is varied; whereas, in the latter set-up, the period of delay prior to response is assumed to be constant and minimum and the number or pattern of reaction alternatives is varied

The laboratory methods which have been used to study the delayed reaction may be divided into two general classes

1. The Carr-Hunter or Indirect Method (the first to be used)
2. The Hunter or Direct Method

We shall briefly describe the distinguishing features of each of these two methods. A third *Observational* or *Anecdotal Method* might be added, although this is a field rather than a laboratory method, no attempts whatsoever being made to control any conditions.

The principle involved in the *Carr-Hunter* or *Indirect Method* is that of first establishing, by so-called "trial-and-error" learning, an association between an arbitrary stimulus (e.g., light, sound, etc.) and a series of locomotor responses on the part of the animal which lead to food. As soon as the animal has become positively conditioned to the stimulus so that it reacts immediately and correctly whenever the stimulus is given, delays are instituted between stimulus and response. Instead of having the animal react while the stimulus is still present, the latter is presented only for a short interval, and then, after a predetermined period of delay, the animal is permitted to make the response and obtain food. The *Carr-Hunter Method* has been used by Hunter (21), Ulrich (45), McAllister (35), and Honzik (20) on the albino rat; by Yarborough (50) on the cat, by Hunter (21) and Walton (46) on the dog, by Hunter (21) on the raccoon, by Rugh (38), Harlow, Uehling, and Maslow (19), and in the present study on infrahuman primates; and by Hunter (21) on the human child.

We now come to the second general method of studying the delayed reaction, the *Hunter Direct Method*. The principle involved in this method is that of utilizing an association, between some stimulus and reward, which has already been formed by the animal, or at least one which is so closely connected with the animal's reactional biography that very little training is required for its establishment. After the animal has become adapted to the experimental situation and has responded a few times, a period of delay is introduced between the presentation of the stimulus and the locomotor or other response on the part of the animal. This direct method has been used by Révész (37) on the chicken; by Maier (33) on the albino rat; by Cowan (9) and Adams (1) on the cat; by Tinklepaugh (42, 43), Buytendijk (6), Nellmann and Trendelenburg (36), Kohts (32), Kohler (31), Yerkes and Yerkes (56), Yerkes (52, 53, 54), Harlow, Uehling, and Maslow (19), Maslow and Harlow (34), and Harlow (17) on infrahuman primates; by Hunter (25), Tinklepaugh (42, 43), Rugh

(38), and Skalet (41) on the human child, and by Harlow and Israel (18) on subnormal humans.

We cannot here present a detailed critique of these methods, although the literature is full of controversies over the relative efficacy of each We can only mention the most salient differences and advantages. It is usually held that the Carr-Hunter or Indirect Method is highly arbitrary that the stimulus (light, sound, etc) has no biological connection with food in most animal forms. This contention is partially borne out by the fact that several hundred trials are often required to establish the association before the period of delay is introduced. Nor is the indirect method adapted to the animal's mode of finding things in nature, in which positional cues play so large a rôle. The Hunter Direct Method, on the other hand, is based on a so-called natural action-tendency of most animals to go directly to food, or to bury food and later recover it when so desired It is less artificial than the Carr-Hunter Method, and motivation is more direct, since there is already an association between food and the searching response Hence no long learning process is required, which makes it more economical of the experimenter's time Kohler (31) is critical of all mechanical choice training problems, for he contends that they afford no basis for insight He maintains that this lack of comprehensible connections is the factor accounting for the relatively poor showing of the primates on such tests, i e., that they cannot give evidence of insight into the problem but must learn by trial and error just the same as the rat and other mammals Buytendijk (6) voices the same criticism, namely, that an attempt is made to use an association which has no biological significance for the animal

In answer to this criticism, exponents of the Carr-Hunter Method hold that the so-called lack of sensible relationship in their problem is not due to the fact that lights have no biological significance for the animal, but rather to the fact that by the use of such a method higher animals, such as the ape, are reduced to exactly the same position as the mammals, and are compelled to form an association from its very beginning rather than to react by making use of a situation which has been previously experienced and has already acquired a certain "meaning" for the animal. Advocates of the indirect method also maintain that this is the only procedure which adequately eliminates the investigator from the experimental

situation and standardizes the presentation of the stimulus, thereby producing controlled conditions which would be impossible with a direct method

It is very difficult to draw the line between the Direct and Indirect Methods. In fact, such a division is made on a relative and not an absolute basis, since they are not mutually exclusive. In fact, many hold that these methods are basically the same, both involving the use of associations which must be established at some time in the animal's reactional biography. To be sure, the two methods differ in the particular associations used, but this may not be of fundamental significance McAllister (35) has compared the difference between the two procedures to that found between nonsense and meaningful material as employed in the investigation of memory in the human subject He contends that, although both have been used, the nonsense material is chosen whenever we wish to study the memory process under more completely controlled conditions.

The studies of delayed reaction by various investigators indicate that the following factors are influential and should be controlled. species and number of subjects used, type of association required, size and location of release mechanism, number and specifications of reaction compartments employed, punishment and reward (motivation should be optimal, and punishment should be used if limits are desired), number of trials daily, time interval between trials (should be at least three times as long as period of delay), and varying brightness of background. The following precautions should also be taken: no cues should be given during period of delay or at the moment of release; position habits should be guarded against; responses to various compartments or stimuli should be in chance order; ability to delay should be tested by commonly used sense avenue; experimenter should be eliminated by a one-way light screen; and a high norm of mastery should be required. These, together with the four major requirements enumerated by Hunter (see above), constitute the most salient features of the typical delayed reaction experiment.

Experiment

Animals. Six Macacus rhesus monkeys were employed during the course of this experiment. Three of these, animals #8, #20,

and #22 (all females) were used only in preliminary tests in which the purpose was the perfection of a method. The remaining three, subjects #2 (female) #9 (male), and #18 (female) were used in the delayed-reaction experiment proper These animals were members of the primate colony of the Columbia Laboratories of Comparative Psychology, being utilized for research in connection with a project on motivation and intelligence, sponsored by the Council for Research in the Social Sciences of Columbia University. They were all young and immature (preadolescent) monkeys at the time of purchase and were obtained from a New York animal dealer. Subjects #2 and #9 arrived at the laboratory in December, 1930, and #18 arrived in February, 1931. All were vigorous, healthy animals whose records may stand as typical. The respective weights of the three subjects at the conclusion of the experiment were as follows: #2, 3019 grams, #9, 3728 grams, and #18, 2849 grams

When first obtained the animals showed no signs of former handling They were then put through the usual handling and general adaptation routine which has been standardized at this laboratory They were subsequently used as subjects in studies on learning in the Jenkins Problem Box, motivation by means of the Columbia Obstruction Method, and imitation by means of the Direct Two-Cage Method Thus by the beginning of this experiment the monkeys were unusually cooperative, and because of their past experience as subjects in the above investigations they soon adapted themselves to the requirements of the delayed-response situation

All of the monkeys were housed throughout the year in separate, specially constructed, indoor cages in the primate quarters of the laboratory. They were fed three times daily according to the standardized Columbia weekly feeding schedule for monkeys, which includes proper proportions of milk, eggs, whole-wheat bread, raw fruits, vegetables, together with cod-liver oil (Aidex tablets) mixed with lactophos. The animals were exercised daily in the runway and also enjoyed a period of Sunlamp stimulation each morning. All routine activities, such as feeding, exercising, cleaning cages, etc, were carried out according to a rigid and non-varying program. It might also be added that each monkey wore a small leather belt around its waist, to which was attached a steel chain approxi-

mately 8 inches long. The end of this chain contained a metal tag bearing the animal's colony number and also a ring, used for fastening the control cord in the various apparatuses.

Apparatus. The apparatus used in this experiment consisted of a steel cage, 72 inches in length and 30 inches in width, covered with a heavy wire screening of ½-inch mesh. (It might be parenthetically noted that the cage used in this experiment was the lower half of a two-deck cage, the upper half having been of a modified form for use in testing imitation.) The floor and ceiling were made of ½-inch veneered flooring, the latter being covered with brown linoleum, and all side and interior walls were 36 inches high from the surface of the floor. The cage was mounted upon heavy, rubber-tired rollers, making the upper surface of the cage floor 7 inches from the floor of the room.

The entrance to the cage was a side-hinged door, 22 inches wide and 35 inches high, extending approximately the entire height of the cage. This was also constructed of ½-inch wire mesh, and was hardly distinguishable from the remainder of the wall. This door was located directly in the center of the front side of the cage, each end of the door being 25 inches from its respective end of the cage. There was also a small, hard-rubber drop door, 14½ inches high and 10 inches wide, situated in the lower center of the entrance door and raised by means of a cord and pulley, although this was not used during the course of the experiment. The large entrance door swung from the left and was equipped with a special bolt which held the door firmly closed at all times. The entire apparatus was painted with aluminum bronzing. A detachable one way light screen, 72 inches long and 36 inches high, was mounted directly against the front side of the cage during the test, so that the experimenter was entirely eliminated from the animal's field of vision, although he could observe the animal very distinctly.

One end of the cage contained the stimuli and reaction-alternatives. A heavy wooden panel was set in the cage, the wire mesh having been removed. This panel was constructed of standard ¾-inch lumber, and was 13 inches high and 29½ inches wide, the bottom of the panel being 12 inches above the floor and the top 11 inches from the ceiling of the cage. The entire panel was painted a standard battleship grey. The wire mesh above and below the panel was reinforced on the outside by heavy, brown

beaver board, so that the animal was unable to see through that entire end of the cage

The panel contained three reaction and incentive compartments together with their corresponding stimulus lights Each compartment consisted of a door, 3 inches square, which opened into a small box, the latter being partially open on the back side so that the experimenter could replenish the incentive whenever necessary. A small brass knob or handle was mounted ¾ inch from the top center of each door, and the doors were hinged from the bottom and opened toward the animal The three doors were 8 inches apart, outside measurements, and the two end doors were 2½ inches from their respective sides of the cage. These two outside doors, 19 inches apart, were the only ones used in this experiment, the knob on the middle door having been removed and the door locked shut. Each door contained a screw eye on the inner side, to which was attached a strong cord, the other end of which was fastened on the back of the corresponding box. These cords served as a means of closing the doors after a correct reaction and also prevented the animal from opening the door when an incorrect response had been made, since the cord to the incorrect door was hooked over a nail and made taut before the stimulus was presented

Directly above the center of each of these doors was a circular aperture, approximately 1½ inches in diameter, the bottom of each aperture being 1¼ inches above the top of the corresponding door. A frosted 25-watt Mazda lamp was situated behind each of these apertures, each lamp being enclosed in a separate light-tight compartment, although a single hinged board served as a common back for all of these compartments so that they would be readily accessible to the experimenter if the occasion should demand Each aperture was covered with milk glass on the inside of the light box so that a more constant and diffused light was to be had

At the other end of the cage were two reflectors, containing a frosted 100-watt and clear 10-watt bulb, respectively These reflectors were 6½ inches in diameter and were situated as closely together as possible, one on either side of the median line of the cage. The centers of the bulbs were approximately 18 inches from both floor and ceiling of the cage These lights were used for general illumination and for signal of the release of the animal

following delay (see *General Method*). A heavy cord projected through the middle of this end of the cage, just above the floor level. This was attached to the subject during the experiment, and the animal could thus be released or drawn back at the will of the experimenter. This end of the cage was adjacent to the wall of the room, the latter serving to obstruct completely the animal's vision.

The three stimulus lights were wired in separate circuits so that each could be turned on and off as desired. They were operated from a control board containing three single-throw switches, one for each circuit (only two of which were used). The two general illumination and signal-of-release lights at the other end of the cage were also wired separately, with snap switches in easy reach of the experimenter as he stood at the control board.

Procedure. Experimental work was conducted daily from 2:00 to 4:30 P.M. in the special test room. The animals were well motivated at such a time, having been without food for at least six hours. Preliminary investigation was begun in February, 1932, and the last experimental data were taken in July of the same year. As has been stated above, the purpose of the preliminary was the perfection of a method, especially as to ways of training, controlling, and releasing the animals, and as to what periods of delay to use with this particular experimental situation. Animals #8, #20, and #22 were used in this connection. Let us now briefly summarize the procedure finally developed and employed in the experiment proper, in which monkeys #2, #9, and #18 acted as subjects. We need only mention the fact that adaptation to the laboratory, keeper, other experimenters and research situations, and to the present investigator had already occurred before the beginning of this study.

The method employed, like all indirect methods, can be divided into training and testing procedures. We shall consider each of these in turn. The subject was transported to the experimental room by means of a specially constructed, drop-door carriage, the animals having previously been trained to jump into and out of this carriage whenever the door was opened, and thus did not have to be touched by the experimenter. Having placed the animal in the apparatus and attached the snap of the control cord to the ring of the animal's chain, the investigator closed and locked the entrance door and placed the one-way light screen across the front of the

cage. The lights of the room were then turned off and an electric fan was started. This furnished a constant noise, or sound screen, which served to eliminate any chance auditory cues or distractions. The two doors to the incentive boxes were then opened, and food was thrown through both doors. The subject, being released each time from its usual position at the far end of the cage, ran forward and procured the food from the floor, directly below the stimulus panel. This procedure lasted for two days, 30 trials being given each day, and served as a general adaptation to the apparatus and experimental situation.

During the next three days the procedure was modified so that the animal, when released, walked forward and took the food from the hand of the experimenter The incentive was presented in chance order, and both doors remained open at all times. The stimulus light above the correct door was turned on before and during the trial The 10-watt lamp burned constantly during the entire experiment, serving as a general source of illumination. This light was chosen so that it would allow the stimulus lights over the doors their maximum relative brightness and consequent attention-getting value, and yet provide adequate illumination for the observation of the animal subject. The 100-watt lamp remained off during the presentation of the stimulus and was turned on simultaneously with the release of the animal In later trials the monkey became so conditioned that this light served as a signal of release, thereby eliminating any cues which might otherwise have been given by the experimenter in such a process Immediately after reaction, this lamp was turned off and the subject was drawn back to the far end of the cage

On subsequent days the training procedure was modified as follows: On the sixth day, 30 trials were given in which the experimenter dropped out of the situation entirely, the incentive being placed directly in one of the two open stimulus boxes, and the animal reacting accordingly. Care was taken to allow only one reaction each trial, since there was a tendency for the subject to go to both boxes regardless of the correctness of his choice The next (seventh) day, the incorrect or non-food door was closed and fastened, the animal going directly to the open door. The light over the correct door was always on during these choices, and 30 trials were given per day The next step (eighth day) was to

exhibit food at the "lighted" door, after which it also was closed, and the monkey was required to react without the incentive's being present at the moment of response Starting with the ninth day, both doors were closed and the animal had to react to the light alone. This was continued for ten days, 300 trials, and marked the final step in the transition from direct to indirect method. Thus 18 days were devoted to the training process, with a total of 540 trials for each animal. At the end of this time the association between stimulus light and incentive had been thoroughly established, since no subject made more than 3 errors in the last 150 of such trials.

The testing procedure was then begun. The stimulus light was turned on over one of the doors and remained on for a period of 5-20 seconds, depending on when the subject attended to it In no case was it necessary to present the light longer than 20 seconds. The light was then turned off *while the animal was looking at it,* and the predetermined period of delay was begun This guaranteed that the animal's actual delay would begin when the experimenter's stop-watch was started rather than at some arbitrarily selected time when the subject was not looking. At the conclusion of the period of delay, the 100-watt lamp at the rear of the cage was turned on and the animal was released to make its choice If the responses were correct, the monkey opened the door and obtained the incentive, after which it was gently pulled back to the far end of the cage If incorrect, the animal found the door locked and returned without food, and the 100-watt lamp was turned off, prior to another trial

Thirteen trials in all were given per day, 10 of these being actual test trials, whereas 3 (the 1st, 5th, and 9th) were trials in which the animal made a direct response to the door while the stimulus light was still on These were given so as to renew the light-food association from time to time and to enhance motivation It also served as an additional check on the animal's original training Thirty test trials were given on each period of delay, 3 days of 10 trials each. The two stimuli were presented in chance order, the following schedule being followed

First day of delay . .	RLRLLRLRRLRRL
Second day .	LRLLRLRRLLRLR
Third day . .	RLLRLRRLRLLRR

A period of 2 minutes intervened between adjacent trials. This is in conformity with the suggestion made by Adams (1) and others to the effect that the period between successive trials should be at least three times as great as the period of delay itself, in order to guarantee that the animal is reacting to the stimulus light rather than to the door wherein food was obtained on the previous trial

The following periods of delay were studied in order: 10, 0, 3, 6, 10, 15, 20, 30, 40, 6, and 10 seconds. Attention is called to the fact that, on the basis of its previous record, animal #9 was dropped during the delay periods of 30 and 40 seconds, and the subsequent delays of 6 and 10 seconds were not administered (see *Results*) It will be noted that the 0-second delay, for example, here means that the animal was released when the stimulus light was turned off, and *not* when the animal reacted The same is true for all the other delays, in that all delay periods are really longer than stated, since the monkey's reaction-time is not included. By noting the general trend in results on a given delay period as well as from period to period, some indication of the effects of practice on delayed reaction might be obtained.

In addition to the number and percentage of correct responses made on every 10 trials of each period of delay, daily observations were recorded concerning any additional features of the animal's behavior which the investigator deemed important. After each day's trials, the animal was returned to its cage, given a few poppy seeds, and fed its afternoon meal. The incentives used in the experiment proper were raisins and small slices of banana on the learning trials and banana and small cubes of apple on the test trials These foods have been found to offer the best motivation for work on the monkey and are in standard use in the Columbia laboratories

Controls. Watson (49) has criticized Hunter's delayed-reaction experiments on the ground that the box in which the light last appeared might have risen in temperature, or else the rise might have been sufficient to increase the diffusion of gaseous particles which in turn would arouse the olfactory receptors. In such a case, the animal would be merely discriminating between the two or more stimuli on the basis of thermal or olfactory sensitivity rather than performing a delayed response to a then absent stimulus In the present experiment, however, these possibilities were entirely avoided The light bulbs themselves were of comparatively low

intensity (25-watt frosted) and both were enclosed in a separate box entirely isolated from the reaction cage. Nor was the stimulus light ever presented for a period longer than 20 seconds, and the exposure was usually considerably shorter. Thus all secondary thermal and olfactory cues from the stimulus lights were eliminated.

Food was always placed in both boxes during test trials, and thus no differential olfactory cues from the incentive itself were offered since the odor of food would be diffused equally in both boxes. The close proximity of the two reaction mechanisms would also make it difficult for the subject to obtain differential cues in any modality. A series of test trials was run in which food was absent from both boxes, and this failed to show any effect on the accuracy of the animal's choices. The only other olfactory cues would be the scent from the animal's own body remaining on the door last used. This is very improbable, and, if such were the case, it would result in a simple position or alternation habit and the subject could never meet the criterion.

As previously stated, auditory cues were eliminated by the use of a sound screen provided by an electric fan. Secondary visual cues from the apparatus were ruled out by making both stimulus doors as nearly identical as possible and by rotating the presentation position of the stimulus in chance order Visual cues from the experimenter and other objects external to the cage were eliminated by the use of a darkened room and one-way light screen The light signal for release served to exclude any tactual cues given by the experimenter in release. The two-minute period between adjacent trials guaranteed that the animal was reacting to the stimulus light rather than to the box where food was obtained on the previous trial.

With the above controls in use, it was concluded that all reactions must have been based on cues not provided by the external situation We shall consider this question at greater length in the later discussion

Results. A glance at Table 1 will show that there are wide individual differences in the ability of the three subjects to react correctly after delay, and that these differences are manifested both in the original 10-second period (before practice) and in every period thereafter (after varying amounts of practice). There was but one major exception to the tendency for the three subjects to

TABLE 1

Showing the Percentage of Correct Responses on Every Ten Trials of Each Successive Delay Period Throughout the Experiment

Data are given for each of the three subjects and for the group as a whole

	10″ delay				0 delay				3″ delay				6″ delay				10″ delay				15″ delay			
	Trials				Trials				Trials				Trials				Trials				Trials			
Animal	1	11	21		1	11	21		1	11	21		1	11	21		1	11	21		1	11	21	
	10	20	30	Av	10	20	30	Av	10	20	30	Av	10	20	30	Av	10	20	30	Av	10	20	30	Av
#18	60	50	60	57	90	100	90	93	80	80	100	87	70	90	100	87	70	80	90	80	60	70	60	63
#20	60	70	60	63	100	90	100	97	100	100	100	100	100	100	100	100	100	100	100	100	80	100	90	90
# 9	40	50	50	47	60	80	70	70	60	70	80	70	70	60	60	63	40	60	70	57	50	40	50	47
Av	53	57	57	56	83	90	87	87	80	83	93	86	80	83	87	83	70	80	87	79	63	70	67	67

	20″ delay				25″ delay				30″ delay				40″ delay				6″ delay				10″ delay			
	Trials				Trials				Trials				Trials				Trials				Trials			
Animal	1	11	21		1	11	21		1	11	21		1	11	21		1	11	21		1	11	21	
	10	20	30	Av	10	20	30	Av	10	20	30	Av	10	20	30	Av	10	20	30	Av	10	20	30	Av
#18	40	60	70	57	50	60	60	57	70	90	80	80	80	90	70	80	100	90	100	97	90	100	90	93
# 2	90	80	90	87	80	80	70	77	60	70	70	67	70	60	60	63	100	100	100	100	100	90	90	93
# 9	60	40	50	50	40	50	50	47	*															
Av	63	60	70	65	57	63	60	60	60	70	67	66	67	67	60	64								

*Dropped (position habit) Counted as 50 in determining average

TABLE 2

SHOWING THE PERCENTAGE OF CORRECT REACTIONS ON EACH OF THE THREE 10-SECOND DELAY PERIODS, TOGETHER WITH THE RELIABILITY OF THE DIFFERENCE BETWEEN THE FIRST TWO SUCH INTERVALS

Data are given for each of the three subjects and for the group as a whole

Animal	10-second delays 1 (before practice)	2 (after practice)	3 (after practice)	D	PE (diff 1-2) σ_{diff}	$\frac{D}{\sigma_{diff.}}$
#18	57	80	93	23	11 62	1 98
# 2	63	100	93	37	8 81	4 20
# 9	47	57	*	10	12 80	78
Av.	56	79	—	23	6.77	3 40

*Dropped (position habit).

retain the same relative rank in ability to react correctly after varying periods of delay Thus animal #2 was the highest through the delay periods up to and including 25 seconds, whereas animal #18 was the highest on delays of 30 and 40 seconds. This reversal may be attributed to learning or practice effect, as we shall later point out.

Although no attempts were made to obtain ultimate limits of delay, so-called "immediate" limits were obtained in the case of two subjects. With a criterion of 80-per-cent correct out of 30 consecutive trials, the maximal delay for subject #2 was somewhere between 20 and 25 seconds. Subject #9 never met the criterion, its best performances being 70- and 60-per-cent correct choices on the 3- and 6-second delay periods respectively This animal developed a position habit toward the middle of the experiment and was dropped. Subject #18 met the criterion during the 40-second delay, and no further attempt was made to obtain an upper limit.

As stated in the introduction, the primary object of this experiment was to study the effects of practice on the delayed response There is no doubt but that the data show positive practice effects. If we compare the scores (percentages) made by each animal on the three 10-second periods, i e., before and after practice, we find marked learning effects Thus the three subjects made scores of 57, 63, and 47 per cent respectively on the original 10-second period, and scores of 80, 100, and 57 per cent respectively on the second 10-second delay period. For the first two subjects (#18

and #2) the reliabilities of the differences are remarkably high, considering that only 30 trials were given.[8] If we take the average for all three subjects, we find an increase from 56 to 79 per cent of correct choices between the two 10-second delay periods, the difference of 23 being more than three times its P.E. This average difference is all the more significant since it includes the data for subject #9, who responded with chance accuracy on both occasions (47 and 57 per cent respectively)

The third 10-second interval was given as a check on the other two, since it came after a period during which the monkeys had been making comparatively low percentages of correct reactions on longer intervals of delay The results show that whatever learning had been accomplished was of a permanent nature, since both animals scored above 90-per-cent correct choices. It might be added that the immediately preceding 6-second interval of delay was administered as a kind of "shock absorber" so as to eliminate any disturbing factors (e.g., position or alternation habits, discouragement, lack of motivation, etc.) should they have existed

A second major evidence for the effect of practice can be seen by inspection of the table of results It will be recalled that every three days a longer interval of delay was introduced, thereby increasing the difficulty of the problem, regardless of the absolute or relative proficiency of the subject In general, there was an inverse relationship between the percentage of correct reactions and the length of delay. If no learning whatsoever existed, a perfect correlation throughout would be expected. It is needless to say that such was not obtained Of especial interest is the record made by subject #18, whose percentages of correct choices decreased as the delay period was lengthened to 25 seconds, at which time she was responding with chance accuracy (57 per cent). On the even longer delay period of 30 seconds, however, this animal made an average of 80-per-cent correct responses, and maintained this average during the succeeding 40-second interval Thus it appears that with the other subjects (#2 and #9) the experimenter increased the difficulty of the problem at a rate which exceeded the rate

[8]Formula for standard error of proportion or simple sampling of attributes was taken from Yule (57), p 269 $\left(E^2_{12} = \frac{P_1Q_1}{N_1} + \frac{P_2Q_2}{N_2} \right)$

of learning of the animal, whereas subject #18 learned more rapidly and thereby on one occasion was able to increase her percentage much more than the experimenter increased the difficulty of the problem. As to exactly how this was accomplished, we can only conjecture The writers venture the opinion that the animal may have learned to utilize some other cue or substitute stimulus which was more effective in eliciting the correct response. This suggestion is in conformity with the usual "explanations" of rises following plateaux in the learning curve on the basis of "change in method." The rather sudden rise in the curve is similar to what the Gestaltists have termed "insight," but this philosophical terminology is only a name for a simple stimulus-response phenomenon.

We might here mention a possible criticism or "objection" to the method and results herein reported, viz., the fact that the first 10-second interval consisted of only 30 trials, while the second might be thought of as consisting of the preceding delay periods of 0, 3, and 6 seconds, making 120 trials in all. This is not an objection or criticism in the least, but exactly what the investigators intended, since the effect of practice was to be studied The main reason for selecting these interpolated delay periods, rather than giving all trials on the same 10-second interval, was the fact that this is the standard procedure inaugurated and used by Hunter and is usually considered better since the difficulty of the problem is increased gradually. The question as to whether there would be more or less practice effect if the delay interval were held constant still remains to be investigated Nor can the difference between the two 10-second intervals be attributed to adaptation, recovery from shock or fright, etc The long preliminary adaptation and training process in which no animal made more than 3 errors in the last 150 trials is enough to preclude any such possibilities.

A third evidence of the influence of practice lay in the slight tendency for improvement during the 30 trials of any delay period Inspection of the results will show that there is a slight though consistent positive trend. The average increase for the three subjects as a group is positive in almost every case, although too much reliance must not be placed on the average in such a small group It will be noted that this increase is not exhibited in the 40-second delay period, possibly on account of the reduction in motivation occasioned by the long delay. Similarly, there is no improvement

in the last 6- and 10-second periods since the animals have reached such a degree of proficiency that there is relatively little opportunity for improvement

There was a tendency for the monkeys to react more slowly as the problem became more difficult, i e., there was a positive correlation between reaction time (post-release and pre-reaction period) and the period of delay, although no quantitative records of this phenomenon were taken throughout the experiment. Thus during the shorter delays the animals reacted almost immediately after release, the only time intervening being that required to traverse the length of the cage On the longer intervals, however, the reaction time became much slower, and on rare occasions was as long as 8 seconds. During such a period the monkey would slowly approach the two doors, look in both directions, and finally choose one, often making a quick "slap" at the handle as if it were a hot object.

Lastly, let us consider the cues or bases of reaction used by the various animals The data here consist of observations of the animal's general behavior. In no case did the experimenter observe the monkey to maintain a gross bodily set, posture, or overt attitude during the delay period In fact, many disorienting movements, cries, etc, always intervened between the presentation of the stimulus and the release prior to reaction. Each animal had an almost idiosyncratic mode of behavior during the delay period Animal #18 usually clung to the rear of the cage grill, facing the release signal and general illumination lights and with her back to the reaction panel. She would turn her head to see the stimulus light and then look in the opposite direction. Animal #2 was a rather "nervous" and "neurotic" animal and would sit on the floor looking at the stimulus light, after which she would bite at her legs and chain, often going through various contortions Animal #9 was a rather slow-reacting monkey who usually sat and gazed at the ceiling and walls of the cage during the delay period Thus the experimental evidence indicates that at least two of the monkeys reacted correctly on the basis of some other cue or substitute stimulus, the exact nature of which cannot be determined from the data collected in this study

References

1. ADAMS, D K. Experimental studies of adaptive behavior in cats. *Comp. Psychol Monog*, 1929, **6**, 122-137

2. ALPERT, A The solving of problem-situations by preschool children an analysis. *Teach Coll Contrib. Educ*, 1928, No 323. Pp viii+69

3. BERNSTEIN, A Über eine einfache Methode zur Untersuchung der Merkfähigkeit resp des Gedachtnisses bei Geisteskranken *Zsch f. Psychol*, 1903, **32**, 259-263

4. BIERENS DE HAAN, J. A Über das Suchen nach verstechtem Futter bei Affen und Halbaffen *Zsch f vergl Physiol*, 1930, **11**, 630-655

5. BUHLER, C Kindheit und Jugend Genese des Bewusstseins (*Psychol. Monographien*, Bd 2) Leipzig: Hirzel, 1928. Pp xx+307 (3rd ed, 1931 Pp 414)

6. BUYTENDIJK, F J J Considérations de psychologie comparée à propos d'experiences faites avec le singe *Ceropithecus* *Arch néerl de physiol.*, 1921, **5**, 42-48

7. COLE, L W Concerning the intelligence of raccoons. *J Comp. Neur & Psychol.*, 1907, **17**, 211-261

8. ———— The Chicago experiments with raccoons. *J. Anim Behav.*, 1915, **5**, 158-173.

9. COWAN, E A An experiment testing the ability of the cat to make delayed response and to maintain a given response toward a varying stimulus *J. Comp Psychol*, 1923, **3**, 1-10.

10. DICE, L R How do squirrels find buried nuts? *J Mammal.*, 1927, **8**, 55.

11. DRESCHER, —, & TRENDELENBURG, W Weiterer Beitrag zur Intelligenzprufung in Affen (einschliesslich Anthropoiden) *Zsch f vergl Physiol*, 1927, **5**, 632.

12. FISCHER, D., & ULLERT, I Contribution à l'étude des tests de memoire immediate *Arch de psychol*, 1929, **21**, 293-307

13. FOLEY, J P., JR. A study of the delayed reaction in the rhesus monkey M A thesis, Columbia Univ, 1932. Pp. 70.

14. FROST, E P The behavior of a grey squirrel *J Anim Behav.*, 1913, **3**, 145-146.

15. GREGG, F. M, & MCPHEETERS, C A Behavior of raccoons to a temporal series of stimuli *J Anim. Behav*, 1913, **3**, 241-259

16. HAMILTON, G V. A study of perseverance reactions in primates and rodents. *Behav Monog*, 1916, **3**, No 13. Pp 65

17. HARLOW, H. F Comparative behavior of primates III Complicated delayed reaction tests on primates *J Comp Psychol*, 1932, **14**, 241-252.

18. HARLOW, H F, & ISRAEL, R H Comparative behavior of primates IV Delayed reaction tests on subnormal humans *J. Comp. Psychol*, 1932, **14**, 253-262.

19. HARLOW, H F, UEHLING, H, & MASLOW, A H Comparative behavior of primates I. Delayed reaction tests on primates from the lemur to the orang-outan *J. Comp Psychol*, 1932, **13**, 313-343

20 HONZIK, C H Delayed reaction in rats *Univ Calif Publ Psychol*, 1931, 4, 307-318

21. HUNTER, W S The delayed reaction in animals and children *Behav Monog.*, 1913, 2, No 6 Pp 86

22 ——— A reply to Professor Cole *J Anim Behav*, 1915, 5, 406.

23 ———. A reply to some criticisms of the delayed reaction *J Phil, Psychol, etc*, 1915, 12, 38-41

24 ——— Review of M W Calkin's *First book in psychology* *Psychol Bull*, 1915, 12, 189-190

25 ——— The delayed reaction in a child *Psychol Rev*, 1917, 24, 75-87

26 ——— The delayed reaction tested by the direct method: a correction *Psychol Bull*, 1929, 26, 546-548

27 KANTOR, J R Principles of psychology (2 vols) New York Knopf, 1924, 1926 Pp xix+473, xii+524

28 KLUGH, A B Ecology of the red squirrel *J Mammal*, 1927, 8, 1-32

29 KOHLER, W Zur Psychologie des Schimpansen *Psychol. Forsch*, 1921, 1, 2-46

30 ———. Über eine neue Methode zur psychologischen Untersuchung von Menschenaffen *Psychol Forsch*, 1922, 2, 390-397

31 ——— The mentality of apes (Trans by E Winter) New York Harcourt, Brace, London. Kegan Paul, 1925 Pp viii+342

32. KOHTS, N Untersuchungen uber die Erkenntnisfahigkeit des Schimpansen Moskow, 1924 (Summarized by R M Yerkes & A Petrunkevitch in *J Comp Psychol*, 1925, 5, 98-108)

33. MAIER, N. R. F Delayed reaction and memory in rats *J Genet Psychol*, 1929, 36, 538-549

34 MASLOW, A H, & HARLOW, H F Comparative behavior of primates II Delayed reaction tests on primates at Bronx Park Zoo *J Comp Psychol*, 1932, 14, 97-107

35. MCALLISTER, W G A further study of the delayed reaction in the albino rat *Comp Psychol Monog*, 1931, 8, No 37 Pp 103

36 NELLMANN, H., & TRENDELENBURG, W Ein Beitrag zur Intelligenzprufung niederer Affen. *Zsch. f vergl Physiol*, 1926, 4, 142-200

37 RÉVÉSZ, G Experiments on animal space perception *Brit J Psychol.*, 1924, 14, 387-414

38 RUGH, D. The simple delayed reaction Unpublished manuscript, Oberlin College, 1929

39 SCHNECK, M R, & WARDEN, C J. A comprehensive survey of the experimental literature on animal retention. *J. Genet Psychol*, 1929, 36, 1-20

40 SHEPHERD, W T Some mental processes of the rhesus monkey *Psychol Monog*, 1910, 7, No 52 Pp 66

41 SKALET, M The significance of delayed reactions in young children *Comp Psychol Monog*, 1931, 7, No 34 Pp 82

42 TINKLEPAUGH, O L An experimental study of representative factors in monkeys *J Comp Psychol*, 1928, 8, 197-237

43. ———— The multiple delayed reaction with chimpanzees and monkeys. *J. Comp. Psychol.*, 1932, 13, 207-243.

44. TOLMAN, E. C. Purposive behavior in animals and men. New York: Century, 1932. Pp. xiv+463.

45. ULRICH, J. L. Integration of movements in learning in the albino rat. *J. Comp. Psychol.*, 1921, 1, 184-199.

46. WALTON, A. C. The influence of diverting stimuli during delayed reaction in dogs. *J. Anim. Behav.*, 1915, 5, 259-291.

47. WARDEN, C. J., JENKINS, T. N., & WARNER, L. H. Introduction to comparative psychology. New York: Ronald Press, 1933. Pp. x+581.

48. WARDEN, C. J., & WARNER, L. H. The sensory capacities and intelligence of dogs, with a report on the ability of the noted dog "Fellow" to respond to verbal stimuli. *Quar. Rev. Biol.*, 1928, 3, 1-28.

49. WATSON, J. B. Behavior: an introduction to comparative psychology. New York: Holt, 1914. Pp. xii+439.

50. YARBOROUGH, J. U. The delayed reaction with sound and lights in cats. *J. Anim. Behav.*, 1917, 7, 87-110.

51. YERKES, R. M. The mental life of monkeys and apes: a study of ideational behavior. *Behav. Monog.*, 1916, 3, No. 12. Pp. iv+145.

52. ————. The mind of a gorilla. Part I. *Genet. Psychol. Monog.*, 1927, 2, 1-192.

53. ———— The mind of a gorilla. Part II. Mental development. *Genet. Psychol. Monog.*, 1927, 2, 377-551.

54. ———— The mind of a gorilla. Part III. Memory. *Comp. Psychol. Monog.*, 1928, 5, No. 24. Pp. 92.

55. YERKES, R. M., & YERKES, A. W. The great apes: a study of anthropoid life. New Haven, Conn.: Yale Univ. Press, 1929. Pp. xix+652.

56. YERKES, R. M., & YERKES, D. N. Concerning memory in the chimpanzee. *J. Comp. Psychol.*, 1928, 8, 237-271.

57. YULE, G. U. An introduction to the theory of statistics. (9th ed.) London: Griffin, 1929. Pp. xv+424.

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L'EFFET DE L'EXERCICE SUR LA RÉACTION RETARDÉE CHEZ LE SINGE RHÉSUS

(Résumé)

Les auteurs discutent les travaux antérieurs dans le domaine de la réaction retardée et comparent les diverses méthodes de laboratoire employées: (1) Carr-Hunter ou Méthode Indirecte, et (2) Méthode Directe de Hunter.

L'intérêt principal de cette étude a été l'effet de l'exercice sur la réponse retardée, en utilisant la Méthode Carr-Hunter ou Méthode Indirecte. Les sujets ont été trois singes rhésus macaques pré-adolescents. Après avoir entraîné les animaux à choisir entre deux portes celle au-dessus de laquelle une lumière comme stimulus s'est montrée, on a commencé des épreuves

de test ou un intervalle de retard s'est interposé entre la cessation de la lumière et la libération de l'animal avant la réponse Les intervalles suivants de retard ont été étudiés en ordre, 10, 0, 3, 6, et 10 secondes, avec 30 épreuves de test dans chaque intervalle de retard On a employé divers contrôles

Les résultats montrent un effet marqué de l'exercice sur l'habileté de deux des trois sujets à répondre correctement après le retard Il y a eu une augmentation prononcée des réponses correctes dans l'intervalle de retard de 10 secondes quand cet intervalle a été précédé de tests sur les plus courts intervalles de retard. D'ailleurs, dans n'importe quel intervalle donné de retard il y a eu ordinairement une petite tendance au perfectionnement pendant les 30 épreuves de cet intervalle L'animal a tendu à réagir plus lentement comme les retards sont devenus progressivement plus longs Il n'a pas fait la réaction sur la base de la posture manifeste du corps

FOLEY ET WARDEN

DIE WIRKUNG VON UEBUNG AUF DIE VERZOEGERTE REAKTION BEI DEM RHESUSAFFEN

(Referat)

Die Verfasser besprechen die Fachliteratur auf dem Gebiet der verzögerten Reaktion, und vergleichen die verschiedenen experimentellen Methoden, die gebraucht wurden (1) Carr-Hunter oder die indirekte Methode, und (2) Hunter direkte Methode

Das Hauptinteresse an dieser Untersuchung war die Wirkung von Uebung auf die verzögerte Reaktion Die Carr-Hunter oder indirekte Methode wurde angewendet Drei sehr junge Macacus Rhesusaffen wurden gebraucht Nachdem die Tiere dressiert wurden, eine von zwei Turen zu wahlen, uber der das Reizlicht erschien, wurden Probeversuche vorgenommen, bei denen eine Verzogerung zwischen dem Aufhoren des Lichtes und dem Loslassen des Tieres eingeschoben wurde Die folgenden Zwischenzeiten wurden untersucht 10, 0, 3, 6, und 10 Sekunden mit 30 Versuchen bei jeder Verzogerungszeit Verschiedene Kontrollen wurden angewendet

Die Ergebnisse zeigen eine bestimmte Uebungswirkung in der Fahigkeit zwei oder drei Tiere, nach der Verzogerung richtig zu reagieren Es war eine ausgesprochene Zunahme der richtigen Reaktionen in der Verzogerungszeit von 10 Sek, wenn Prufungen mit kurzeren Verzogerungszeiten diesen Prufungen vorangegangen waren Im ubrigen war gewohnlich eine kleine Neigung zur Verbesserung innerhalb irgendeiner gegebenen Verzogerungszeit wahrend der 30 Versuche jener Zwischenzeit Es fand sich eine Tendenz des Tieres, langsamer zu reagieren, wenn die Verzogerungen fortschreitend langer wurden Die Reaktion erfolgte nicht auf Grund der offenbaren korperlichen Haltung

FOLEY UND WARDEN

STRING-PULLING BEHAVIOR OF THE CAT*

From the Psychological Laboratory of Brown University

C. K. Trueblood and K. U. Smith

The present note records a repetition and amplification of experiments made by D. K. Adams (1), dealing with the abilities of cats to obtain food in situations which require horizontal string-pulling. The devices used by Adams included a cubical cage, without bottom, of 1½-inch wire mesh, with top and sides 1 yard by 1 yard, the lower edges of the sides being slightly raised above the floor. Strings were so laid on the floor as to emerge from this cage as indicated in *A, B, C, D*, of Figure 1. To one of the strings was attached food, or a small pan containing food.

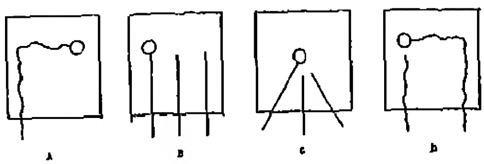

FIGURE 1

In situations such as these, Adams reports, cats are able to discriminate strings to which food is attached from strings to which no food is attached, whether the unattached strings are arranged parallel to the loaded string, as in *B*, or whether they are made to converge upon the food, as in *C*, or whether the loaded string is laid in the form of an L, as in *D*. The cat also, according to Adams, readily obtains food in the situation indicated in *A*. The reported distance separating the ends of the non-loaded strings from the food varied from 5 to 8 cm. Among Adams' conclusions are the following:

> Some cats did learn to pull strings, and in most of these cases one success was sufficient to accomplish perfect learning (1, p 122)
>
> With proper introduction and adaptation of the animals to

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> the experiment room and to the situation of being alone therein, all cats would learn to pull strings in the situations used, and most of them would learn with one success. (1, p 122)
>
> The behavior of most of the animals in the horizontal string pulling problems permits the inference of practical ideas In most of these cases maximum efficiency appeared in the second or third experience (1, p. 155)

So far as can be ascertained from the experiments reported by Adams, these declarations are based on observations of relatively few animals with relatively few trials given to a single animal—one trial only with some animals. The experimenter was also at times in the experimental room at the moment of response of the animal, no controls being specifically indicated as to whether this fact did or did not affect behavior Nor are controls mentioned of olfaction, or of position habits as possible influences affecting the performances, and, although the description of behavior implies that discrimination was visual, no controls are submitted demonstrating its visual character

Since such experiments as these seem important, at least in affording premises for arguments that cats and other of the lower mammals are capable of "insight," a repetition and slight extension of Adams' experiments in horizontal string-pulling has been attempted, the effort being to answer two questions (1) Can the cat, in one trial, develop a visually determined response habit to a string to which food is attached; (2) can it, in one trial, visually discriminate such a string from one or more similar strings placed nearby with no food attached?

The arrangements described by Adams were duplicated in the first part of the present experiments as nearly as available facilities permitted Modifications were later introduced, these will be explained hereafter. The cage used was of the dimensions and design already described The food was placed in a shallow circular white pan, 5 inches in diameter, to which was attached a white string. In making the strings, white cheese-cloth was rolled into strands and then braided The result was a soft, closely packed, braided string, approximating 1 inch in diameter. Unattached or non-loaded strings were of the same sort as the attached or loaded strings and the length of all strings was so regulated that no matter where emerging they would extend at least 1 foot beyond the edge of the cage Used strings were frequently replaced with fresh ones Cage, strings,

and food-pan were placed in the center of an experimental room, upon a pressed-wood base, 3/16 of an inch thick, painted black, and extending 2 feet beyond the edges of the cage.

The cat, when released from a small wooden restraining cage controlled from outside the room, proceeded toward the experimental cage, where, if successful, it obtained the food by clawing out the string to which the food-pan was attached. Raw liver, cut in ½-inch squares, was the food used in the earlier part of the experiments. It was later replaced by an equal amount of canned salmon. When the cat had eaten the food it was at once returned to the release box and the procedure repeated. The animal was always alone in the room from the moment of its release to the moment it had finished eating the food. Observations and motion pictures of its behavior were made from an adjoining room by means of a small aperture in the door. Experiments were carried on between nine and eleven o'clock in the evening, an average of ten trials being given in each experimental session.

Common cats of unknown pedigree were used. Some of them had been previously used in puzzle-box and other experiments, but none had participated in string-pulling under experimental conditions. They had been confined to the laboratory quarters for two months or more prior to the experiments here reported and during that time had been fed with milk and with a mixed diet of cooked meat scraps. For the duration of the experiment, however, they had only milk and the food obtained in the course of the experimental sessions. This ordinarily sufficed since ten or more trials were given daily.

Single-String Experiments

Four animals were successively introduced to the experimental situation by being fed three consecutive evenings in the center of the experimental room near the cage. They were then required to obtain food by clawing out a single string to which the food-pan was attached, and which emerged from the cage in the manner already described. Cat 1 obtained the meat in this manner in a first trial lasting 11 minutes and 31 seconds, cat 2 in a first trial lasting 7 minutes and 23 seconds. Cat 3 failed to solve the problem in 15 minutes and was then removed from the room. It obtained the food the next evening in 9 minutes and 20 seconds. Cat 4 required six consecutive 15-minute trials on as many evenings before it solved

the problem, the successful performance being made after 12 minutes 41 seconds during the seventh 15-minute trial.

These animals were then given additional trials in which the position of the string was changed from one side of the cage to another after each trial. None of the cats learned to proceed immediately to the side of the cage where the string lay. All of them persisted in clawing at empty sides of the cage, particularly at that side where the string had been in the last preceding trial. Cat 1 eliminated this tendency only after the 20th trial, cats 2 and 4 at the 16th trial. Cat 3 had not eliminated this tendency at the 12th trial, when it was transferred to a multiple-string situation. Motion pictures were taken of this behavior.

Eight additional animals, none of which had been used in any prior experiments, were now submitted to the single-string situation. They were *not* fed in the experiment room before being presented the problem Of these animals, cat 5 succeeded in 1 minute 47 seconds, in the second trial, cat 6 in 2 minutes 50 seconds, also in the second trial. Of the remaining six cats, three had not solved the problem after eight successive 15-minute trials, and the other three had not solved it after ten such trials These animals were all active. All of them clawed at various empty sides of the cage throughout the trials, as well as at the general region of the cage where the string emerged.

Cat 6 was given additional trials in which the position of the string was changed from one side of the cage to another after each trial This animal frequently made the characteristic error of clawing at empty sides of the cage The time it required to obtain the food in successive trials with rotated position of the string was: first trial, 2 minutes 50 seconds, second trial, 2 minutes 44 seconds, third trial, 4 minutes 31 seconds; fourth trial, 4 minutes 45 seconds; fifth trial, 2 minutes 47 seconds; sixth trial, 1 minute 15 seconds; seventh trial, 42 seconds.

These experiments suggest that the preliminary feeding at the cage, which is possibly what Adams means by "proper introduction and adaptation of the animals to the experiment room," plays a significant rôle in the apparent solution in one trial of the single-string problem. But the performances of the cats in those situations in which the position of the string is rotated about the cage throw doubt upon the assertion that the behavior permits the inference of so-called "prac-

tical ideas" in cats, at least of "practical ideas" that the loaded string is an object to be pulled in order to obtain food. If the phrase "practical ideas" has any meaning in this connection, such "ideas" as the cat possesses would seem to be of movements to be made in certain regions of the situation, movements which distinctly cannot be said to have an infallibly direct perceptual reference to the string, or to be exclusively determined by vision, else the cat would more promptly respond to changes in position of the string. We do not mean, of course, that some cats may not be able to learn, by a series of trials and errors, or even by that acquisition in a single trial which is termed "insight," to respond promptly and on a demonstrably visual basis to changes in position of the loaded string, or to discriminate visually a food-loaded string from non-loaded strings placed nearby. We do mean that none of the twelve animals performing in these first experiments gave convincing evidence in a single trial of visually determined specific responses to the loaded string as an object to be pulled in order to obtain food.

To gain information as to whether cats could learn, either by a series of trials and errors or by "insight," to respond visually to a string as an object to be pulled in order to obtain food, and to discriminate visually a food-loaded string from non-loaded strings, the experiments were continued by submission of the animals to multiple-string situations, some being the same as those employed by Adams, and some being additional.

Multiple-String Experiments

Four animals, cats 13, 14, 15, 16, were presented with the five multiple-string situations indicated as *A, B, C, D, E,* in Figure 2. Arrows indicate the path taken by the animals in approaching the experimental situation. Table 1 summarizes the percentages of correct responses exhibited by each cat in each of the five arrangements. Trials are shown at the extreme left of the table Notations at the bottom of the table indicate experiments in which the positions of the loaded and non-loaded strings were reversed in successive trials. An error was counted if the animal responded to a non-loaded string by touching it

Cat 13 After being trained in the single-string situation already described, this animal was presented with the multiple-string situation D, the positions of the loaded and the non-loaded strings remaining

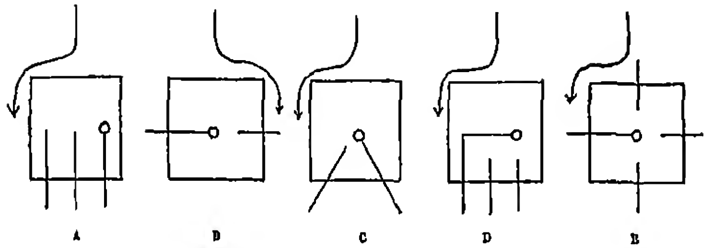

FIGURE 2

constant throughout successive trials, and the animal being slightly punished whenever it responded to the non-loaded strings by being immediately removed from the experimental situation Under this treatment it learned to discriminate the loaded from the non-loaded strings within 40 trials. No time records were taken for these trials, but the successful behavior of the animal after 40 trials had been given was recorded by motion pictures.

This cat was then presented with the multiple-string arrangement A The three strings occupied the same position throughout all trials, the ends of the non-loaded strings being separated from the food-pan by 5 or more inches in this and all other multiple-string experiments described herein. Throughout the first five trials the animal pulled *both* non-loaded strings before pulling out the food-loaded string. During the third five trials, and henceforth, it responded to the loaded string alone. Motion pictures were taken of the first twelve trials The time the animal required to secure food diminished gradually from 35 seconds on the first to as low as 10 seconds on the last trials In general, in this and the other multiple-string experiments, elimination of responses to non-loaded strings took place gradually In first trials the cat would drag the non-loaded strings completely from the cage Later it merely touched the non-loaded strings, when responding to them. Ultimately it even ceased touching

Cat 14 This animal was not trained in the single-string situation but was submitted directly to the multiple-string situation A after being fed for three consecutive evenings in the experimental room near the cage The three strings occupied the same positions throughout all trials. After eight consecutive daily trials of 15 minutes each the cat learned to obtain the food by immediately

clawing the loaded string from the cage. On the 9th trial the animal obtained the food after 2 minutes 20 seconds. On the 11th trial this time increased to 3 minutes and 24 seconds. By the 25th trial the time had decreased to as low as 9 seconds. The reduction of error during the 30 trials is indicated in Table 1. Motion pictures were taken of the behavior of the animal in this situation.

TABLE 1

TRIALS AND PERCENTAGE OF CORRECT CHOICES MADE BY EACH CAT DURING TEN TRIALS IN SITUATIONS A, B, C, D, E

String arrangement→		A		B	C	D		E
Trials	#13	#14	#15	#15	#16	#13	#15	#15
0- 10	0	20	* 60	60	* 0	0	0	* 0
10- 20	100	50	50	100	50	10	0	0
20- 30		80	100		50	40	0	40
30- 40					50	100	0	30
40- 50					60		0	10
50- 60					90		0	0
60- 70					70		0	0
70- 80					80		0	0
80- 90					80		0	
90-100					80		0	

*Experiments in which the positions of the strings were reversed in each trial.

Cat 15. This animal was trained in the single-string situation and then presented with multiple-string situation A. With this animal, however, the positions of loaded and non-loaded strings were regularly interchanged during successive trials. Beginning with the 20th trial the animal discriminated the loaded from the non-loaded string, irrespective of position. The time required to obtain the food decreased gradually from 15 seconds on the first, to four seconds on the last trial. Motion pictures were taken of the behavior of the animal.

This cat was next presented with the multiple-string situation B, the relative positions of loaded and non-loaded strings remaining constant throughout all trials. In the first ten trials the animal responded six times to the non-loaded string before pulling the loaded string from the cage. Thereafter it responded to the loaded string alone. The time required to secure the food decreased gradually from 18 seconds on the first to 7 seconds on the last trial.

The animal was next presented with the multiple-string situation

D, the position of loaded and control strings remaining constant throughout successive trials. The error of responding to non-loaded strings was made in all 100 trials given this animal. In 92 of the trials the cat responded to both non-loaded strings before pulling the loaded string.

Finally, this cat was presented with the multiple-string situation E, the positions of loaded and non-loaded strings being interchanged after each trial. In only 8 of the 80 trials given did the cat respond to the loaded string without previously responding to one or more of the non-loaded strings. In six of these eight "correct" trials the loaded string lay at the side of the cage nearest the entrance and hence first in the animal's path as it approached the cage turning toward the right, as it invariably did. The other two "correct" responses were also on the right side of the cage.

Cat 16. This animal was trained in the single-string situation and then presented with multiple-string situation C, the positions of the loaded and non-loaded strings being reversed during successive trials. After 100 trials the cat exhibited 80-per-cent-correct discriminations of the loaded string. The time taken to obtain the food decreased from a mean of 10.3 seconds in the first ten trials to a mean of 7.7 seconds in the last ten trials. Motion pictures were taken of the behavior of the animal in this situation.

While the results of the foregoing experiments are suggestive rather than conclusive, it is nevertheless apparent that these cats could not in one trial respond selectively to a food-loaded string placed among non-loaded strings. Within certain limitations they could learn, or apparently learn, to do so in a series of trials and errors, but the limitations throw doubt on the assumption that the selective responses of the cats to the loaded string were based wholly on "practical ideas," visually derived, of the loaded string as an object to be pulled in order to obtain food.

To assume, as Adams apparently does, that the cat can in one trial exhibit an "insight" into the multiple-string situation, or a "practical idea" of the loaded string as an object to be pulled in order to obtain food, necessitates, we believe, the further assumption that the cat is capable in one way or another of visually perceiving the *continuity* of the loaded string and the *discontinuity* of the non-loaded strings with the food-pan or the food. Discrimination as prompt and accurate as this could, we believe, be on no other basis

But if the cat possesses such a capacity for visual response it should be able to act accordingly, no matter how the strings are arranged, provided the arrangement permits clear vision of the essential continuities and discontinuities involved, and we believe that it does in all the multiple-string situations herein described.

But the behavior of these cats in the situations described, while suggesting that some form of visual response may have been a factor in the ultimate successes of the animals, is nevertheless far from demonstrating that the responses in question involved visual perceptions of continuity and discontinuity of loaded and non-loaded strings with the food-pan. If these responses had involved such perceptions, there ought to have been no marked variation in the capacity of single animals to respond discriminatively in different types of multiple-string situations. Yet there clearly was such variation. It is obvious that these cats more readily learned to discriminate a loaded string in a situation which involved two strings than in one which involved more. And they did better in a situation involving parallel strings than in one which the loaded string was angled or bent before it emerged from the cage. Further, it is clear that the ability of the animals to respond selectively to a loaded string was less affected by altering the positions of loaded and non-loaded strings in a parallel-string situation than by such interchanges in the more complex situations described.

From this behavior it would appear that there is an alternative to supposing that the cat's successes are due to its perception of the continuity of the loaded string with the food-pan. One may as easily, or perhaps more easily, suppose that the cat's apparent visual responses to the loaded string and food-pan are really visual responses to the food-pan alone, and the animal solves the multiple-string situations presented to it, not by immediately perceiving the continuity of the loaded string and food-pan but by learning (by a series of trials and errors) to take up certain positions with reference to the food-pan, and then go through what are, in the early trials at least, more or less random clawings having but little direct perceptual reference to the string, the result of this process being in successive trials the continual and gradual decrease in non-effective acts.

Such an inference has support not only from the fact of the frequent and useless fumblings of all animals at empty sides of the cage in the single-string situation, but also from the characteristic errors

of several animals in the multiple-string situations Cats 13 and 15 furnish examples of such errors Cat 13, trained in 40 trials (with punishment) to select only the loaded string in the bent-string situation D, was submitted to the parallel-string situation A For 10 of the 15 trials required to initiate the new habit, the animal consistently proceeded first to the *region of the cage* where the loaded string had emerged in the previous bent-string arrangement rather than to the string that was now visibly continuous with the food-pan Similar behavior could be observed in the performances of cat 15. This animal was trained, in approximately 30 trials, to select the loaded string in the parallel-string situation A, the positions of loaded and non-loaded strings being interchanged during successive trials It was then presented with the bent-string situation D, in which the food-pan appeared in line with one of the non-loaded strings but with the inner end of the non-loaded string visibly separated from the food-pan by a distance of 5 inches In 100 trials the animal did not learn to distinguish the loaded from the non-loaded strings It pulled always those strings which lay *in line with* the food-pan before it pulled the loaded string The behavior of this animal in multiple-string situation E is also significant in this connection The food-pan in this latter situation was placed in the center of the cage and hence equidistant from all sides of the cage, though visibly continuous with one string and visibly discontinuous with the three other strings by at least 5 inches. The cat made no progress with this problem in the 80 trials given, whereas in other multiple-string situations in which the food-pan was displaced from the center toward one or another of the sides of the cage the animal made definite progress toward a solution of the problem in less than 80 trials In performances such as these it would seem that no true visual discrimination of loaded from non-loaded strings takes place

In view of these considerations, the question naturally arises: Is it possible to arrange an experimental situation in which the cat will develop demonstrably and exclusively visual responses to the continuity between the loaded string and the food-pan or to the discontinuity between the non-loaded string and the food-pan? In an attempt to find this out two additional cats were subjected to the double-string situation F shown in Figure 3.

The cage was moved to the side of the room, the animal being thus compelled to reverse its steps after making an incorrect choice

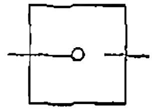

FIGURE 3

The base of the cage was so arranged that the food-pan could be returned always to the exact center of the cage. Special strings were cut from ¼-inch white felt, 1 inch wide and of such lengths that loaded and non-loaded strings extended the same distance outside the cage. As before, clean strings were frequently substituted for used ones to control possible olfactory influences. The end of the non-loaded string, which was invariably separated from the food-pan by at least 10 inches, was attached to the base of the cage by a small invisible hook so that the animal in responding to the string would be slightly punished by not being able to pull it. The positions of the loaded and the non-loaded strings were interchanged in irregular order after each trial.

The results are shown in Table 2. Of the two cats submitted to this situation, while one developed 76-per-cent correct discriminations of the loaded string in 250 trials, and the other 60-per-cent accuracy in 375 trials, neither ever showed the perfection of response

TABLE 2

PERCENTAGE OF CORRECT CHOICES AND AVERAGE TIME IN SECONDS DURING SERIES OF 25 TRIALS IN SITUATION F

Subject→	#17		#18	
Trials	Per cent correct	Average time	Per cent correct	Average time
0- 25	12	10.6	20	34.4
25- 50	28	9.7	40	10.8
50- 75	24	8.3	24	13.1
75-100	8	7.8	20	11.6
100-125	48	10.5	40	11.0
125-150	32	10.7	36	11.8
150-175	16	10.2	44	11.1
175-200	36	10.2	32	9.2
200-225	52	11.8	36	9.7
225-250	76	11.8	48	9.4
250-275			68	8.4
275-300			64	8.2
300-325			72	12.6
325-350			60	12.6
350-375			60	9.2

which one would reasonably expect of animals responding visually to the continuity of loaded strings and food-pan and which, we believe, is necessarily implied by "insight" or by "practical ideas" of loaded strings as objects to be pulled in order to obtain food. It is true that controls of the performances of cat 17 showed that the distance between the end of the non-loaded string and the food-pan was to some extent *a* factor in the discrimination Thus in 25 trials given this animal with the end of the non-loaded string separated from the food-pan by 5 instead of 10 inches, accuracy of response dropped to 64 per cent, rising to 100 per cent in 15 succeeding trials in which the usual 10-inch interval was restored. Again, in 15 trials in which the end of the non-loaded string was separated from the food-pan by 2 inches, accuracy of response dropped to 53.4 per cent, rising again to 86.7 per cent when the 10-inch interval was restored Yet when the method of control was slightly changed, for example, with the substitution of a food-pan, like the usual 5-inch pan in all respects except that it was 2 inches in diameter instead of 5, the distances between the end of non-loaded string and food-pan remaining 10 inches as before, accuracy of response dropped to 33 1-3 per cent, rising again to 84 per cent in 25 trials with restoration of the original food-pan.

The fact is thus apparent that the supposed visual responses of these two cats to continuity or discontinuity of loaded and non-loaded strings with food-pan could not have been exclusively or even significantly visual perceptions of such relations, since these animals patently lacked the accuracy of performance which responses of this sort would necessarily involve Far from the cat's being able in one trial, as Adams reports, to discriminate accurately a loaded from a non-loaded string when the end of the non-loaded string lies as near as *5 cm* to the food-pan, we find that this response is still equivocal after 250 trials have been given one animal and 375 trials another animal with the end of the non-loaded strings as far as *10 inches* from the food-pan.

Summary

Fourteen cats were trained and tested in various situations requiring the animals to pull strings in order to obtain food "Successful" responses were secured in certain situations, but when the situations were altered by the elimination of extraneous clues upon the basis of

which position habits had presumably been established, the responses were found to have no relevance to the continuity or discontinuity of the strings with the food Further, when two additional cats were trained for approximately 300 trials each under altered conditions, equivocal responses were still obtained, even though the food and the inner end of the unattached strings were separated by as much as 10 inches. Moreover, in such successful responses as were attained by the animals in these situations one success was not "sufficient to accomplish perfect learning", nor did maximum efficiency appear in "the second or third experience" In general, the behavior of the animals in these situations does not appear to require the inference of either the "ideas" or the "insight" implied by Adams On the contrary, like the performances of the cat in another experiment reported from this laboratory (2), such successful responses as were achieved appeared as a result of the gradual elimination of non-effective acts—that is, of trial-and-error learning.

References

1 Adams, D K. Studies of adaptive behavior of cats. *Comp Psychol. Monog.*, 1928-1929, 6, 114-162.

2 Carmichael, L, & Marks, L D A study of the learning process in the cat in a maze constructed to require delayed response. *J Genet Psychol*, 1932, 40, 206-209

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LE COMPORTEMENT DU CHAT EN TIRANT DES FICELLES

(Résumé)

Dans la répetitions de certaines expériences de D K Adams, on a entraîné et testé quatorze chats dans des situations où il a fallu que les animaux tirent des ficelles pour obtenir de la nourriture Les chats ont obtenu la nourriture en tirant des ficelles dans certaines de ces situations, mais quand on a changé les situations dans les expériences de contrôle en éliminant les repères sur la base desquels ils auraient établi leurs habitudes de position, les réponses n'ont montré aucune relation avec la continuité de la ficelle correcte ni avec la discontinuite des ficelles incorrectes avec la nourriture D'ailleurs, quand on a entraîné deux autres chats, chacun dans approximativement 300 épreuves dans des conditions semblables, on a toujours obtenu des réponses équivoques, bien que la nourriture et les bouts intérieurs des ficelles incorrectes aient été séparés de la longueur de dix pouces D'ailleurs, dans les reponses réussies obtenues, un succès n'a pas "suffi pour accomplir un apprentissage parfait," comme Adams avait dit. En général, le comportement des animaux dans ces situations

ne nécessite ni la supposition des "idées" ni celle de la "connaissance approfondie" données à entendre par Adams Les réponses réussies obtenues se sont montrées comme résultat de l'élimination graduelle des actes non effectifs, c'est-à-dire, par l'apprentissage "essai et erreur"

TRUEBLOOD ET SMITH

FADENZIEHENDES VERHALTEN DER KATZE

(Referat)

Bei der Wiederholung gewisser Experimente von D K Adams wurden vierzehn Katzen dressiert und in Situationen geprüft, wo die Tiere Faden ziehen mussten, um Nahrung zu bekommen Die Katze erhielt die Nahrung durch das Ziehen der Faden in einigen von diesen Situationen, aber wenn die Situation bei Nachprüfungsexperimenten durch die Ausschaltung der Leitfaden verändert wurde, auf Grund derer Stellungsgewohnheiten wahrscheinlich gelernt wurden, hatten die Verhaltungsweisen keine Wichtigkeit in bezug auf die Verbundenheit des richtigen Fadens oder die Unverbundenheit der unrichtigen Faden mit der Nahrung. Weiter, wenn noch zwei Katzen zu ungefähr 300 Proben, jede unter denselben Umständen, dressiert wurden, wurden unbestimmte Reaktionen noch erhalten, obgleich die Nahrung und die inneren Enden der unrichtigen Faden bis auf zehn Zoll getrennt wurden Im übrigen war ein Erfolg bei erfolgreichen Reaktionen nicht hinreichend, um perfekt zu lernen, wie Adams behauptet hat Im allgemeinen erfordert das Verhalten dieser Tiere in diesen Situationen die Folgerung von weder "Ideen" noch von "Einsicht," was von Adams auch behauptet wurde Solche Reaktionen schienen das Resultat einer allmählichen Ausschaltung nichtwirksamer Akte, d. h durch Versuch und Fehler, zu sein

TRUEBLOOD UND SMITH

THE SPREAD OF THE INFLUENCE OF REWARD TO CONNECTIONS IRRELEVANT TO THE LEARNER'S PURPOSES*[1]

EDWARD L THORNDIKE AND THE STAFF OF THE DIVISION OF PSYCHOLOGY, INSTITUTE OF EDUCATIONAL RESEARCH, TEACHERS COLLEGE, COLUMBIA UNIVERSITY

We have shown elsewhere that a satisfying after-effect not only strengthens the connection which it immediately follows and to which it belongs, but also strengthens to a much less degree connections near enough to the rewarded connection though these are themselves punished. The satisfying after-effect does not, in this spread of its influence, act logically, but in a natural, not to say mechanical, way. It acts directly, not by virtue of any secondary behavior on the part of the subject, who would be no more likely to repeat or otherwise cherish punished connections near to the rewarded connection than those remote from it.

In the present series of experiments we inquire whether a satisfying after-effect will also spread to connections which are contemporaneous with the rewarded connection and unpunished, but irrelevant to the learner's purposes.

The experimenter instructs the subject as follows:

> I shall say a word, you will say any number from 1 to 6 as soon as you hear the word. You will also say any letter Then I will say another word and you will say 1, or 2, or 3, or 4, or 5, or 6 as before and any letter, but you must not use the same letter twice in succession and you must not use any device or sequence of letters like a for the first word, b for the second word, c for the third word, d for the fourth word, etc You can always choose any number from 1 to 6 as you please, but the letters that you choose must not be chosen by any system. After you have said a number and letter, I shall say "Right" or "Wrong" This announcement of "Right"

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[1]The investigation reported in this article was part of a general investigation of learning made possible by a grant from the Carnegie Corporation

> or "Wrong" refers to the numbers only You will not have to be told whether any letter is right or wrong, because, as a matter of fact, none of the letters is right and none of them is wrong They are not to be learned as the numbers are, but are for an entirely different purpose You understand that the best that you can possibly expect to do in the first trial is to get one right out of every six Moreover, going as fast as we do with rather difficult material to remember, you must not expect to get anywhere near perfection in the small number of trials that we make The money payment made to you as a bonus after each division of the experiment will show you how rapidly you are learning We shall also tell you the total number of rights made by you in each division of the experiment The number you would get by chance is 33 Consequently anything over that means learning
>
> We will do a practice series to make sure that you have the procedure in mind and to show you about the rate at which the words and numbers will be said.

The subjects were 24 adult students, to whom the money was an important matter The materials used were 24 sets, each consisting of 40 words, for each of which some number from 1 to 6 was called "Right," the other five numbers being called "Wrong" as responses to that word A subject was put through a series of 40 five times without stop He then had a rest of about two minutes during which he was told his score and given his money bonus. This was repeated set after set for an hour On later days, usually in three more sessions, the rest of the 24 sets were used in the same way.

The experimenter said a word, recorded the number and letter said by the subject, and announced "Right" or "Wrong," the total time for such a unit averaging 3 56 seconds and varying from 3.1 to 4.0 seconds according to the quickness of response of the subject.

The word-number connections to which the satisfying "Right" and money payment are attached are strengthened in all the subjects. This does not now concern us, except as evidence that the satisfying after-effect had potency

Our present interest is to discover whether the connection between a certain word and the *letter* which the subject used with the number as his response was strengthened by the reward, which referred only to the number

We compare the percentage of repetitions of the same letter in

response to a word in cases where the number in the response was rewarded by "Right" and money, with the corresponding percentage in cases where the number was punished by "Wrong" and no money. We measure first the influence of single and first occurrences only That is, we use the influence of trial 1 upon trial 2 in all 960 connections, the influence of trial 2 upon trial 3 omitting the cases of all connections which were identical in trial 1 and trial 2, and the influence of trial 3 upon trial 4, omitting the cases of all connections in trial 3 which were identical with those operating in trial 1, or in trial 2, or in both [2] We shall study the double and treble occurrences later. We reserve the influence of trial 4 on trial 5 for possible later study.

Table 1 presents the facts in its first six columns and the comparison in column 7 (differences in strengthening in favor of the word→letter connection contemporaneous with a rewarded word→number connection)

The totals for all 24 subjects give .281± 0031 (P E.) as the probability of repetition of a letter attached to a rewarded connection and .242±.0014 (P.E.) as that of a letter attached to a punished connection. The difference 039 is over 10 times its probable error (.0034) In 17 of the 24 subjects there appeared a positive influence of occurrence along with a rewarded connection [3] The mean difference is 4 0; the median is 2 3.[4]

[2]Identical here means having the same word and the same number; the letter might be the same or different.

[3]The exact nature of the connections ending in a letter said need not concern us They may be, and probably are, different in different individuals. Common forms probably are

(1) word→number
word↘letter

(2) word→number→letter (these will vary according to the prominence of the word-to-letter and number-to-letter elements)

(3) word→number→letter

(4) word→number I must say a letter too→letter

In some forms, in which the saying of a letter is taken care of by a habit or habits highly independent of those concerned in listening to the word and choosing a number, the attachment is very slight. No. 4 above verges toward such a condition. In some forms, such as No 1 above, where the letter is almost a co-response with the number to the same situation, the attachment is very close All that concerns us in this investigation is that, whatever the different sorts and degrees of attachment may be, the average result differs for attachment to rewarded and to punished connections It will be an interesting investigation to analyze individuals' connection forms, and correlate the differences in these with differences in the amount of spread. The seven subjects who showed no evidence of spread may well have used forms of connection to letters different from the seven who showed large amounts of it

[4]We have also carried out computations separately according as the

TABLE 1

THE SPREAD OF THE INFLUENCE OF THE REWARD GIVEN FOR A CORRECT NUMBER TO THE LETTER SAID BY THE SUBJECT ALONG WITH THAT NUMBER IN RESPONSE TO THE WORD IN QUESTION

The frequency with which a connection which at its first occurrence was related to a rewarded or punished connection as stated, was repeated (*S*) or replaced by a different connection (*D*) in the next trial

	Word-number→letter connections: With a rewarded word→number conn			With a punished word→number conn			Diff.	Word→number connections: Rewarded			Punished			Diff
	S	D	$\frac{100S}{S+D}$	S	D	$\frac{100S}{S+D}$	3-6	S	D	$\frac{100S}{S+D}$	S	D	$\frac{100S}{S+D}$	10-13
Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	68	285	19.3	341	1428	19.3	0.0	138	205	39.1	547	1222	30.9	8.2
2	155	251	38.2	670	1227	35.3	2.9	133	273	32.8	393	1504	20.7	12.1
3	194	193	50.1	752	1147	39.6	10.5	145	242	37.5	374	1525	19.7	17.8
4	98	302	24.5	276	1599	14.7	9.8	170	230	42.5	349	1526	18.6	23.9
5	110	261	29.6	502	1451	25.7	3.9	111	261	29.8	381	1571	19.5	10.3
6	52	340	13.3	232	1593	12.7	0.6	228	164	58.2	371	1454	20.3	37.9
7	233	140	62.5	834	988	45.8	16.7	164	210	43.9	437	1383	24.0	19.9
8	212	176	54.6	768	1012	43.1	11.5	188	200	48.5	409	1371	23.0	25.5
9	69	343	16.7	303	1446	17.3	—0.4	195	217	47.3	418	1331	23.9	23.4
10	75	317	19.1	403	1401	22.3	—3.2	155	237	39.5	462	1342	25.6	13.9
11	90	304	22.8	391	1464	21.1	1.7	182	212	46.2	359	1496	19.4	26.8
12	198	183	52.0	812	956	45.9	6.1	191	190	50.1	430	1338	24.3	25.8
13	111	305	26.7	322	1429	18.4	8.3	257	159	61.8	384	1367	21.9	39.9
14	99	273	26.6	508	1370	27.1	—0.5	175	207	45.8	385	1493	20.5	25.3
15	136	269	53.6	648	1243	34.3	—0.7	105	300	25.9	435	1456	23.0	2.9
16	114	272	29.5	554	1328	29.4	0.1	141	244	36.6	413	1469	21.9	14.7
17	113	279	28.8	332	1548	17.7	11.1	244	148	62.2	340	1540	18.1	44.1
18	61	331	15.6	301	1521	16.5	—0.9	130	262	33.2	409	1413	22.4	10.8
19	53	344	13.4	268	1602	14.3	—0.9	123	274	31.0	411	1465	21.9	9.1
20	80	270	22.9	275	1427	16.2	6.7	161	189	46.0	510	1192	30.0	16.0
21	58	343	14.5	254	1555	14.0	0.5	166	235	41.4	418	1391	23.1	18.3
22	71	287	19.8	299	1469	16.9	2.9	217	141	60.6	427	1341	24.2	36.4
23	104	253	29.1	364	1439	20.2	8.9	113	244	31.7	457	1346	25.3	6.4
24	43	332	11.5	207	1653	11.1	0.4	197	178	52.5	349	1511	18.8	33.7
All	2597	6653	28.1	10616	33296	24.2	3.9	4029	5222	43.6	9868	34047	22.5	21.1

In spite of the fact that they were told that the letters could be neither right nor wrong and made no difference in the score, some of the subjects said the number and the letter to themselves when the former was called right, if they had time to do so before the next word was said by the experimenter. However, those who did not do so showed nearly or quite as large differences as those who did. Apparently their repetition did not connect the letters with the words.

To check further on this, we have repeated the experiment with five members of the Institute staff who were instructed never to repeat word or letter and to prevent such from echoing as a memory after-image in the mind One of the five did not succeed in the latter, another was so disturbed by efforts to avoid repetitions and echoes and association of letters with the words that there was no influence of the reward in his case. The other three gave the following results for the influence of one occurrence.

With a rewarded word-number connection S 245, D 1007, % 19 6
With a punished word-number connection S 884, D 4601, % 16.1

The difference (3 5) is little below that (3 9) for the group of Table 1

We may then assume that, if all the 24 subjects had followed the instructions and paid no attention whatever to the letters save to say one after saying a number, the spread effect of irrelevant association with one rewarded connection would still have been nearly 30.

We may also consider the superior strengthening of the word→letter connections associated with rewarded word→number connections in comparison with the superior strengthening of rewarded word→number connections over punished word→number connections in the same person. Columns 8 to 14 of Table 1 present the facts and comparison for the word→number connections comparable to those of columns 1 to 7 for the word→letter connections

The facts for the totals are as follows.[5]

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first occurrence was in trial 1 or in trial 2 or in trial 3 It makes no demonstrable difference

[5]The percentages of repetition for rewarded word-number connections in this experiment may be partly due to inner repetitions of the number, or of the word and the number, in such cases This was not forbidden because our interests in the experiment did not include a measurement of the con-

Probability of repetition of a rewarded word→number connection	436± 0035 (P E.)
Probability of repetition of a punished word→number connection	225± 0013 (P E.)
Difference	211± 0037 (P E)

The effect of the reward upon the attached neutral connection was then from a sixth to a fifth of that upon the rewarded connection itself

We may now consider the frequency with which *two* occurrences of a response to a word by the same number and same letter are followed by a repetition of the letter in the next trial We record separately the facts for the influence of such double occurrences in trials 1 and 2 upon the response in trial 3, and for the influence of those in trials 2 and 3 upon trial 4, and for those in trials 1 and 3 upon trial 4

The facts for the consecutive doubles appear in Table 2 The probability of repetition in the next trial thereafter is .581 when the letter is attached to a rewarded connection, and .435 when it is attached to a punished connection. The difference, .144, is 12 times its probable error. For the three extra subjects, the corresponding difference is 135

The facts for the non-consecutive doubles are too scant to be presented by individuals The probability of repetition in the trial following the second occurrence is .411 when the letter is attached to a rewarded conection ($n=224$) and 401 when it is attached to a punished connection ($n=635$) [6] For all doubles the probabilities are 554 and 427, the difference, .125, being 11 times its probable error These figures may be compared with the following for the word→number connections rewarded, 800, punished, .325, difference, 475

The facts for the repetition of "trebles" in trials 1, 2, and 3 in trial 4 are as follows Of 265 connections ending in letters attached to rewarded word-number connections, 229 or 86 4%, were

firming tendency set up by the influence of the reward apart from any such repetition, but only its spread to preceding and succeeding word→number connections and to the contemporaneous word→letter [or (word+number)→ letter, etc] connections There was very little time for such inner repetition, and its beneficial influence is probably slight, but the percentages should be used with their source in mind

[6] For the three extra subjects, the corresponding figures were 421 ($n=19$) and .167 ($n=66$)

TABLE 2

THE SPREAD OF THE INFLUENCE OF A REWARD

The frequency with which a connection which, at both its first and second or both its second and third occurrences, was related to a rewarded or punished connection as stated, was repeated (S) or replaced by a different connection (D) in the next trial

	Word-number→letter connections							Word→number connections						
	With a rewarded word→number conn			With a punished word→number conn.			Diff	Rewarded			Punished			Diff.
	S	D	$\frac{100S}{S+D}$	S	D	$\frac{100S}{S+D}$	3-6	S	D	$\frac{100S}{S+D}$	S	D	$\frac{100S}{S+D}$	10-13
Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	14	16	46.7	26	74	26.0	20.7	16	14	53.3	46	54	46.0	7.3
2	34	22	60.7	61	35	63.5	— 2.8	37	19	66.1	29	67	30.2	35.1
3	56	19	74.7	70	55	56.0	18.7	53	22	70.7	35	90	28.0	42.7
4	28	18	60.9	23	36	39.0	21.9	39	7	84.8	14	45	23.8	61.0
5	24	11	68.6	51	55	48.1	20.5	24	11	68.6	55	71	33.0	35.6
6	10	19	34.5	6	28	17.7	16.8	25	4	86.3	7	27	20.6	65.7
7	87	13	87.0	108	54	66.6	20.4	85	15	85.0	61	101	37.6	47.4
8	82	20	80.4	96	66	59.2	21.2	85	17	83.3	52	110	32.1	51.2
9	17	31	35.5	15	67	18.3	17.2	44	4	91.7	23	59	28.1	63.6
10	21	9	70.0	45	85	34.6	35.4	23	7	76.7	50	80	38.4	38.3
11	17	19	47.3	21	51	29.2	18.1	28	8	77.8	21	51	29.2	48.6
12	76	21	78.4	136	48	73.9	4.5	80	17	82.5	67	117	36.4	46.1
13	28	42	40.0	27	58	31.8	8.2	65	5	92.9	29	56	34.1	58.8
14	23	23	45.1	47	40	54.0	— 8.9	43	3	93.5	34	53	39.1	54.4
15	19	17	52.8	49	61	44.5	8.3	22	14	61.2	30	80	27.3	33.9
16	19	17	52.8	56	57	49.6	3.2	31	5	86.2	34	79	30.1	56.1
17	48	23	67.6	22	42	34.4	33.2	68	3	95.8	18	46	28.2	67.6
18	7	17	29.2	20	61	24.7	4.5	19	5	79.2	30	51	37.0	42.2
19	15	12	55.6	12	49	19.7	35.9	19	8	70.4	11	50	18.1	52.3
20	15	33	31.3	37	82	31.1	0.2	42	6	87.5	50	69	42.0	55.5
21	7	21	25.0	14	61	18.7	6.3	25	3	89.3	23	42	35.4	53.9
22	10	38	20.9	20	51	28.2	— 7.3	34	14	70.9	23	48	32.4	38.5
23	23	12	65.8	45	62	42.1	23.7	25	10	71.5	39	68	36.4	35.1
24	8	23	25.9	9	41	18.0	7.9	28	3	90.4	16	34	32.0	58.4
All	688	496	58.9	1016	1319	43.5	14.4	960	224	81.1	777	1548	33.4	47.7

repeated in trial 4. Of 162 connections ending in letters attached to punished word-number connections, 89, or 54.9%, were repeated in trial 4. The difference in probability of repetition is thus .315. Of 265 rewarded word-number connections, 238, or 89.8%, were repeated in trial 4. Of 162 punished word-number connections, 79, or 48.8%, were repeated in trial 4. This difference in probability is thus .410. These results are in harmony with those presented for single and double occurrences.

We have demonstrated that a reward influences not only the rewarded connection itself but also a contemporaneous neutral connection attached to the rewarded connection. The influence of a satisfier spreads backward and forward to influence neighboring punished connections of the same sort as the rewarded connection; it spreads sideways to influence connections that are operative at the time and attached to the rewarded connection as unconsidered parts of it or accessories to it.

In our experiment the attachment of the connection ending in the letter and the connection ending in the number may have been close, but it will be easy to measure the spread of the influence of a reward to contemporaneous connections less closely attached. For example, the subject could say a number and letter and write either a line, cross, circle, or triangle, and also press with his left hand any one of *n* keys. An observer could record his various changes of posture, gestures, smiles, yawns, and the like, and we could measure the frequency of repetition of such in relation to their occurrences along with rewarded and with punished connections. Presumably there is less and less influence with less and less close attachment.

Our experiment adds to the evidence showing that a satisfying state of affairs exerts a strengthening force that is real, regular, and predictable. We may think of it as like a stream of strengthening poured down upon the connection which the reward immediately follows and to which it "belongs," which spreads out to earlier and later connections and to more and more loosely attached contemporaneous connections. Or we may think of it as a unit of strengthening which is directed in general toward the connection to which it "belongs" but which sometimes scatters and hits an earlier or a later connection or an attached accessory connection. A continuous spread or a scattering of shots would equally well account for the experimental results.

L'EXPANSION DE L'INFLUENCE DE LA RÉCOMPENSE AUX CONNEXIONS ÉTRANGÈRES AUX BUTS DE CELUI QUI APPREND

(Resumé)

Un effet ultérieur satisfaisant, c'est-à-dire, une recompense, rend plus forte non seulement la connexion qu'il suit et à laquelle il appartient, mais aussi une connexion contemporaine de la connexion récompensée mais non récompensée elle-même, et etrangère aux buts de celui qui apprend Vingt-neuf sujets ont participé à un apprentissage à choix multiple où la réponse correcte a été suivie d'un signal ("Juste") indicatif du succès et d'une récompense pécunière à payer plus tard Le sujet a fait au hasard, avec ses réponses dirigées au but et appropriées, des reponses secondaires et on lui a dit que l'on ne considererait celles-ci ni justes ni fausses et que celles-ci n'influeraient du tout ni sur son résultat ni sur sa récompense Ces réponses secondaires étrangères sont néanmoins associées plus fortement à la situation quand on recompense la réponse primaire que dans le cas contraire L'effet ultérieur satisfaisant exerce un pouvoir confirmant ou fortifiant qui s'étend ou se repand pour influer sur les connexions contemporaines auxquelles il n'appartient pas logiquement.

THORNDIKE ET AL

DAS VERBREITEN DES EINFLUSSES DER BELOHNUNG AUF ZUSAMMENHAENGE, DIE DEN ZWECKEN DES LERNENDEN UNZUTREFFEND SIND

(Referat)

Eine befriedigende Nachwirkung, d h eine Belohnung, verstarkt nicht nur den Zusammenhang, dem sie folgt, und dem sie gehort, sondern auch einen Zusammenhang gleichzeitig mit dem belohnten Zusammenhang, der nicht selbst belohnt ist und der den Zwecken des Lernenden unzutreffend ist Neunundzwanzig Vpn beschaftigten sich mit vielfachem Wahllernen, bei dem die richtige Antwort von einem Zeichen ("richtig") gefolgt wurde, und das Erfolg und eine Geldbelohnung bedeutete Zusammen mit den zweckmassigen und treffenden Antworten der Versuchsperson, machte sie aufs Geratewohl Nebenantworten, die als weder richtig noch unrichtig gezahlt wurden, wie ihr gesagt wurde, und gar keinen Einfluss auf ihre Marke oder ihre verdienste haben wurden Diese unzutreffenden Nebenantworten werden trotzdem mit der Situation starker in Beziehung gebracht, wenn die primare Antwort belohnt wird, als wenn nicht Die befriedigende Nachwirkung ubt einen bejahenden oder verstarkenden Einfluss aus, der sich auf den Einfluss gleichzeitiger Zusammenhange ausbreitet, denen er nicht logisch gehort

THORNDIKE ET AL

SHORT ARTICLES AND NOTES

AN ARRANGEMENT OF PRINTING-CUBES WITH COMBINED INK-PAD AND TYPE-CELL

Marie L H Forbes

The purpose of this note is to describe a printing device with combined ink-pad and type-cell.

The writer acknowledges the examination of the device by her former instructor, Dr Walter F. Dearborn (1), M D, Director of the Psycho-educational Clinic, Harvard University, and Dr Elizabeth E. Lord, Research Associate, Children's Hospital, Boston

The device consists in part of a box the lid of which in two sections, hinged, serves as a printing-shelf The paper is inserted under a blotter attached to the shelf or under the shelf on a curving slide. It is then folded over the shelf and held down by a guide with printing-cells The paper is constantly pulled toward the back of the shelf away from the operator

For the printing of words in a line, tape is passed over the shelf from right to left through slits in the blotter

Printing-cubes rest on ink-pads spread on the floors of trays which rise in tiers to the printing-shelf The cubes in a tray are divided into groups of five by a bridge in the center of the tray and are separated by wire cross pieces

Capital and small letters of rubber are mounted on adjacent sides of a cube and the sides opposite are indexed with the same stamp, capital and small letter

The cubes are arranged in typewriter order, or, as it has been suggested to the writer, in the order of frequency (2) of letters in composition, small letters of rubber resting on the ink-pads, small letter indices visible

q	w	e	r	t	y	u	i	o	p	e	t	a	i	s	w	y	p	g	h
a	s	d	f	g	h	j	k	l		l	u	c	m	f	v	y	p	g	h
z	x	c	v	b	n	m				v	h	j	q	x	z				

The writer suggests the following additions or modifications A record sheet in motion directly under the printing cells, color in index and ink-pad, a geometric figure mounted on a cube, a digit and a group of domino dots mounted on adjacent sides of a cube and a cube without index or with a raised index.

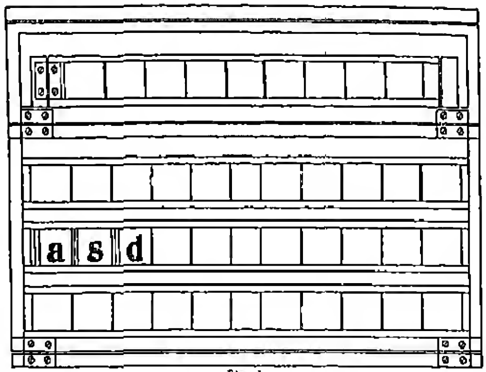

Fig 1

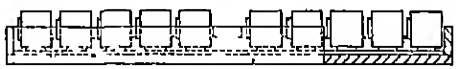
Fig 2

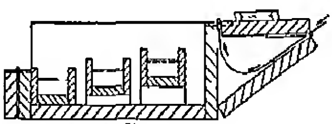
Fig 3

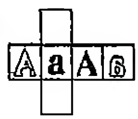
Fig 4

The Drawing:

Figures 1 and 3	Box with trays, printing-shelf, and guide with printing-cells
Figure 2	Tray with bridge, wire cross pieces and cubes on ink-pad
Figure 4	Diagram of double-case printing-cube.

Specifications:

Box	14" x 5½" x 2¼"
Lid of box (two sections)	14¾" x 2¾", 14¾" x 3½"
Tray	13½" x 1" x ¾"
Bridge	1" x 1"
Wire cross piece	1¼" x 1/16" D
Guide	11¼" x 1" x ¼"
Cube	1"

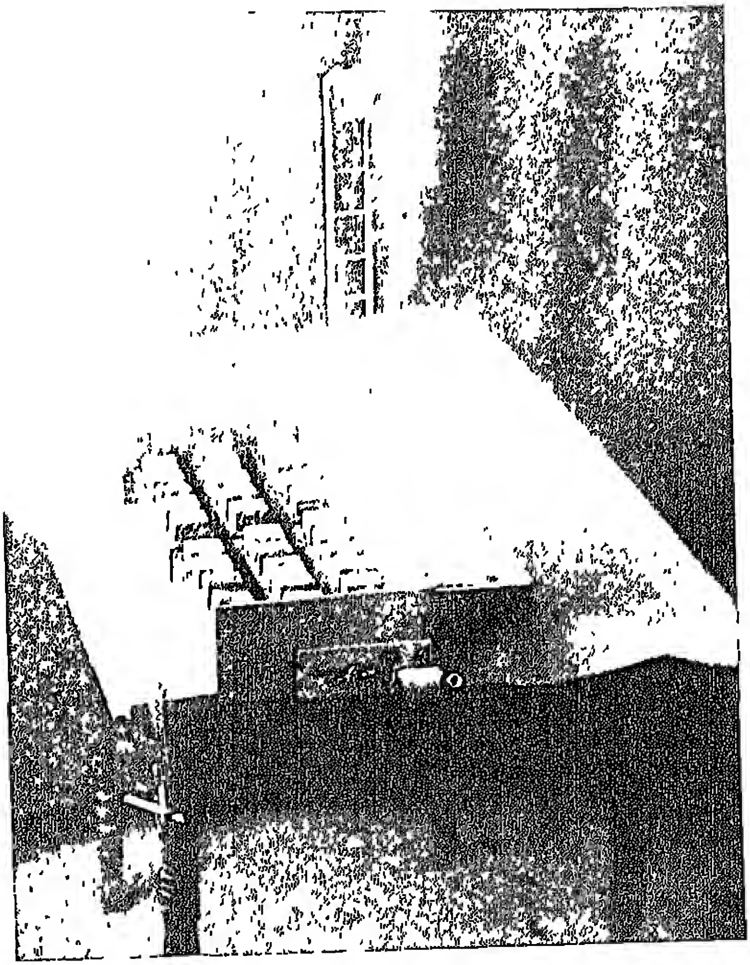

FIGURE 5

REFERENCES

1 DEARBORN, W F Teaching reading to non-readers *Elem School J*, 1929, 30, 266-270

2 THE NEW INTERNATIONAL ENCYCLOPEDIA (2nd ed) New York Dodd Mead, 1923, 19, 216

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BEHAVIOR OF WHITE RATS ON ROTATED MAZES

C K Trueblood and L F Beck

The experiments reported here concern the behavior of white rats when a maze which they have learned is rotated 45 or more degrees from the position of learning, the living-cage of the animals being continuous with the maze and rotating with it. Such an experiment, employing an alley type maze, has been reported by Leuba and Fain (6), who state that no disturbance due to rotation was exhibited by the four white rats which they tested

The results which they have reported suggest that continuity of the living-cage with the maze eliminates the room environment as an influence affecting the behavior of an animal traversing the maze, even when the maze used does not exclude sensory influences arising from the room Such a conclusion, however, contradicts, at least in part, the experimental findings of Carr (1), Patrick and Anderson (7), and Trueblood (9), all of which support the view that the room situation of the maze exerts influence according as the form of maze used permits sensory influences from the room to reach the receptors of the animal in the maze As stated by Carr (1, p. 304)

> the maze habit consists essentially of a tactual-kinesthetic motor coordination, [but] it is dependent nevertheless, both during and subsequent to its development, upon a wider sensory situation of which it is a part This fact is proved by an experimental control of the relations between the animal and the environment

The issue between the results reported in the Leuba and Fain experiment, based on the performances of four animals, and those obtained by the other experimenters mentioned above, based on the performances of upwards of 400 animals, has seemed to us of sufficient importance to justify a repetition of the Leuba and Fain experiment, employing a larger number of animals than they used and using more than one type of maze and maze situation

Accordingly, 48 male white rats, Wistar stock, ranging in age from 130 to 170 days, have been submitted to rotation procedure on an elevated maze, the living-cage being continuous with the maze entrance throughout training and rotated trials, as described by Leuba and Fain Other experiments are in progress in which the animals are submitted to rotation procedure in an alley maze, with the living-cage continuous with the maze, also in accordance with the conditions described by Leuba and Fain

In the elevated-maze experiments, which are here reported, the maze was composed of 9 segments, 2 inches wide, elevated 50 inches above the floor, and mounted on a swivel permitting rotation to any point of the compass The length of the true pathway was 190 inches A sliding gate

of metal, placed midway of the first segment, controlled the release of the animals for timing purposes It was operated by the experimenter, who was stationed behind a screen placed 5 feet from the maze. Illumination was direct and was supplied from above the maze by two 200-watt lights mounted on a frame which rotated with the maze

The living-cage units, provided with wooden floors and meshed-wire top and sides, were constructed in the shape of octagons, measuring 20 inches between any two sides Each octagonal unit was 9 inches high and was divided into 8 individual compartments by wire partitions, 9 x 10 inches, which ran from each angle of the octagonal structure to its central axis Each of these compartments, which was used to house one rat, was equipped with a carpet of sawdust, shredded paper for a nest, a water bottle, and a wire door hinged to the wooden bottom and opening outward This door formed one of the eight exterior faces of the octagon

These cage units were kept in a rack near the maze Each unit was provided with protected apertures at its center so that it could be mounted on a short vertical shaft fixed at the beginning of the maze in such a manner as to revolve horizontally The unit could then be turned until the compartment of any particular animal was directly in front of the initial runway of the maze The wire door could then be lowered and the animal would pass directly from its nest to the maze. Thus, throughout training and rotated trials the cage of each animal was continuous with the true pathway of the maze

Throughout the experiment each animal received four trials in the morning and four trials at night, being allowed to eat for 20 seconds after a trial Successive trials of any one animal were separated by the trials of its seven neighbors in the unit, so that for each animal there was an interval of 6 to 8 minutes between trials Individual glass food dishes, changed regularly from rat to rat, were employed, and each dish, with any food remaining in it, was placed in the cage with the animal at the conclusion of four trials McCullom's diet (3, p 55) was used, being fed as an uncooked meal mixture Two and a half grams were given each animal at a four-trial session In addition, fresh lettuce and crumbs of dog biscuit moistened with cod-liver oil were fed regularly.

Each of the 48 animals received 112 training trials with the maze in the same position, hereafter called the control position This considerable number of trials, which extended over 14 days, was given in order to secure the maximum stability in the performances of the animals at the control position

In the several rotated series, which immediately followed the training series, trials 1 and 2 were given with the maze in the control position, and trials 3 and 4 in either the control position or a rotated position, the respective positions following a regular sequence control, rotated, rotated, control, etc Rotated positions of the maze for any single test series were distributed

among the 48 animals as follows (*a*) 16 rats, maze rotated 90 degrees from the position of learning; (*b*) 16 rats: maze 180 degrees from the position of learning; (*c*) 16 rats: maze 270 degrees from the position of learning. In the next successive rotated series the rats of the (*a*) group would be run from the (*b*) position, those of the (*b*) group from the (*c*) position, and so on. This schedule of rotated and control trials continued for 9 days, and included 12 series in which trials 3 and 4 occurred in rotated positions, and 6 series in which all trials were from the control position. A final group of trials, continuing over three days, included 2 series in the control position and 4 series with the maze rotated successively 45, 135, 225, and 315 degrees from the control position.

The results of this rotation procedure with the elevated maze are indicated in Table 1. The left half of the table shows the mean performance times in

TABLE 1

MEANS, STANDARD DEVIATIONS, AND INTERCORRELATIONS OF RUNS 3 AND 4 IN THE CONTROL AND ROTATED SERIES

Control series (0° position)						Rotated series (all positions combined)					
Trial	M_3	σ_3	M_4	σ_4	r_{34}	Trial	M_3	σ_3	M_4	σ_4	r_{34}
*1	4.9	71	4.9	71	92						
*2	4.7	.76	4.7	72	.93						
						1	8.6	5.90	6.1	1.49	70
						2	6.9	2.07	5.6	1.44	57
3.	5.1	.77	5.0	78	91						
						3	6.9	2.71	5.9	1.76	61
						4	6.2	1.49	5.3	95	.73
4	5.0	.78	4.9	.73	.90						
						5.	5.9	1.66	5.1	79	55
						6.	5.7	1.14	5.2	81	79
5	4.9	.75	4.8	72	93						
						7	5.1	86	4.7	66	79
						8.	5.0	79	4.8	78	89
6	5.1	87	4.9	82	93						
						9	5.1	.63	4.9	65	82
						10	4.9	73	4.7	76	90
7	4.6	77	4.6	.67	91						
						11.	4.9	77	4.6	66	82
						12.	4.9	.66	4.7	.62	91
8	4.6	76	4.6	69	.91						
						†13	5.1	98	4.7	.67	61
						†14	5.1	81	4.8	.75	.74
9.	4.8	.83	4.6	72	.88						
						†15.	5.1	97	4.7	71	81
						†16	5.0	71	4.7	.64	77
10	4.7	.81	4.6	71	95						

*Trials 1 and 2 are taken from the last two trials of the preliminary training series.

†45°, 135°, 225°, 315° positions combined.

seconds, the standard deviations, and the intercorrelations of trials 3 and 4 throughout the several control series, these two trials being the most stable of the four trials and hence affording the best standard of comparison for revealing the effects of rotation. The right half of the table shows the mean performance times in seconds, the standard deviations, and the intercorrelations of trials 3 and 4 in the several rotated series. The spaced arrangement of the table follows the schedule of rotated and control trials, two successive series in the rotated position being always preceded and followed by a series in the control position Errors, i e, entrances and explorations of blind alleys, were rare Their effects on performance times were controlled by recording only the time the animal spent in traversing the true pathway

With the maze in rotated positions the behavior of all the animals shows disturbances of performance In the first place, the mean performance times of trials 3 and 4 in the first rotated series are approximately 50 per cent greater than those of the corresponding trials of the preceding control series, and the correlation coefficient, .70, is lower than the control value of 93, while the standard deviations for the early rotated trials show considerable increases over the corresponding control trials Secondly, analysis of individual performance times shows that every animal requires more time for trials 3 and 4 in the earlier rotated series than for trial 2 in these same series (trial 2 having occurred in the control position), although trial 2 in the control series had taken longer, on the average than trials 3 and 4 Thirdly, while the influence of rotation as revealed in mean performance times becomes slight after the sixth rotated series, yet the general stability of the rotated performances does not reach the level of the control performances until the tenth or twelfth rotated series And, finally, rotation of the maze to new positions (45, 135, 225, 315 degrees from the control position) again reveals significant reduction of correlation cofficients and increases in mean performance times

Such results indicate, we believe, that, while the influence of the room environment on an animal traversing the maze obviously diminishes when living-cage and maze are made continuous, as in the Leuba-Fain experiment, nevertheless this procedure by no means eliminates the room environment as a factor in maze orientation so long as an elevated maze is used and the animal's receptors remain exposed to sensory influences from the room In other words, Carr's original statement would seem still to be true, at least so far as the elevated maze is concerned, namely, that "the maze habit is dependent, both during and subsequent to its development, upon a wider sensory situation of which it is a part"

References

1 Carr, H Maze studies with the white rat *J Anim Behav*, 1917, 7, 260-275, 277-294, 295-306

2 Gengerelli, J A The effect of rotating the maze on the performance of the hooded rat *J Comp Psychol*, 1928, 8, 377-384.

3. GREENMAN, M J., & DUHRING, F. L Breeding and care of the albino rat for research purposes Philadelphia Wistar Instit Anat & Biol., 1923 Pp 109
4. HIGGINSON, G D The performance of the white rat in a rotated maze *J. Comp Psychol*, 1930, 10, 355-373
5. HUNTER, W S Some labyrinth habits of the domestic pigeon. *J Anim. Behav*, 1911, 1, 278-304.
6. LEUBA, J. H, & FAIN, V Note on orientation in the white rat *J Comp Psychol*, 1929, 9, 239-244
7. PATRICK, J R, & ANDERSON, A C. The effect of incidental stimuli on maze learning with the white rat *J Comp Psychol*, 1930, 10, 295-306
8. PORTER, J. P Further study of the English sparrow and other birds *Amer J. Psychol*, 1906, 17, 248-270
9. TRUEBLOOD, C K. The behavior of white rats in a rotated tunnel maze. *J Genet. Psychol*, 1932, 40, 330-350.
10. WATSON, J B Kinaesthetic and organic sensations: their rôle in the reactions of the white rat to the maze *Psychol Rev Monog. Suppl*, 1907, 8, No. 33. Pp. vi + 100.
11. YOAKUM, C. S Some experiments upon the behavior of squirrels *J. Comp Neur. & Psychol*, 1909, 19, 541-568

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THE INFLUENCE OF IRRELEVANT CONTINUING DISCOMFORT UPON LEARNING*

EDWARD L THORNDIKE AND THE STAFF OF THE DIVISION OF PSYCHOLOGY OF THE INSTITUTE OF EDUCATIONAL RESEARCH, TEACHERS COLLEGE, COLUMBIA UNIVERSITY

It is common experience that certain forms of discomfort interfere with learning by preventing the subject from attending adequately to his tasks. The facts of ordinary life, however, are complicated and confused. So it seems worth while to measure the influence of a specified discomfort upon a single form of learning.

The discomfort chosen was the rather mild one of holding one arm in a horizontal position. It was kept mild by permitting the subjects to change the arm at will. The learning consisted in hearing a series of 40 word-number pairs and then responding by a number to each of the 40 words in four consecutive trials in which the words alone were said by the experimenter Twenty series, each containing 40 word-number pairs, were used in four sessions on four different days as follows.

*The experiment reported here was part of an investigation of the psychology of learning supported by a grant from the Carnegie Corporation

Session 1	Series 1	Four trials	Ordinary conditions
	" 2	" "	One arm held out horizontally (The subjects were permitted to shift from one arm to the other at will)
	" 3		Ordinary conditions
	" 4		One arm held out horizontally, as in Series 2
	" 5		Ordinary conditions
" 2	" 6 to 10	with the same arrangements	
" 3	" 11 to 15	" " " "	
" 4	" 16 to 20	" " " "	

In all cases the 40 words and numbers were read once rapidly at the rate of approximately one per second by the experimenter, and then the words were read alone, the subject responding to each by a number from 1 to 10 and the experimenter announcing "Right" or "Wrong," and saying the next word without delay The time per unit (word said by E + number said by S + "Right" or "Wrong" said by E) varied around three seconds

The instructions were as follows:

> This is an experiment in learning sometimes without, and sometimes with, discomfort I have a list of words with numbers attached to them, the numbers running from 1 to 10 Listen comfortably At the end of one quick reading of the list you will tell me which numbers follow the various words and I shall answer "Right" or "Wrong" Twice during one session of the experiment you will keep your left arm raised horizontally all through Don't worry about the time of raising your arm, as I shall tell you when to do that Please give me your answers promptly after each word is read you
>
> We will try it first with a short practice series

(Then a short practice was given with ordinary conditions and another with the arm held out)

Before each series with discomfort, the following was said:

> During this entire set you will keep your left arm raised horizontally If holding out your left arm bothers you, shift to the right arm One arm must be upraised from the time I read the list of words and numbers until you finish giving your answers

Sixteen adult students served as subjects. Their average achievements in each trial of each session were as shown in Table 1 The average accomplishment under discomfort periods 2 and 4 was better than that under ordinary conditions in periods 1, 3, and 5 (9 44 versus 9 05), but not quite so good as that in period 3 alone (9 44 versus 9 39)

We may make a valuable comparison of certain features of learning with

TABLE 1

EXPERIMENT 1 LEARNING WITH DISCOMFORT—NUMBER OF CORRECT RESPONSES

	Period 1 Series 1, 6, 11, 16 Ordinary					Period 2 Series 2, 7, 12, 17 With discomfort					Period 3 Series 3, 8, 13, 18 Ordinary				
Trial	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
Session 1	6.9	6.3	7.4	5.9	6.6	8.0	7.9	7.9	8.1	8.0	8.1	9.6	9.3	9.9	9.2
2	7.8	7.3	7.3	8.0	7.6	7.8	8.5	8.9	9.3	8.6	10.1	9.6	9.7	10.9	10.1
3	8.3	7.5	7.4	7.3	7.6	9.6	9.2	10.6	10.4	10.0	10.2	9.9	10.9	10.9	10.5
4	7.6	7.8	8.5	9.0	8.2	8.8	8.7	10.3	10.3	9.4	9.4	10.2	9.9	9.7	9.8
Session 1–4	7.7	7.2	7.6	7.6	7.5	8.5	8.6	9.4	9.5	9.0	9.5	9.8	9.9	10.3	9.9

	Period 4 Series 4, 9, 14, 19 With discomfort					Period 5 Series 5, 10, 15, 20 Ordinary				
Trial	1	2	3	4	Total	1	2	3	4	Total
Session 1	8.4	8.9	9.3	10.0	9.3	9.8	9.5	9.8	10.1	9.8
2	8.9	9.8	10.9	9.6	9.8	10.1	10.1	11.1	11.6	10.7
3	10.1	10.2	10.4	11.1	10.4	8.9	8.5	8.6	9.4	8.8
4	9.6	10.3	10.1	10.8	10.2	8.8	9.6	9.8	10.5	9.7
Session 1–4	9.3	9.8	10.2	10.3	9.9	9.4	9.4	9.8	10.4	9.8

TABLE 2

THE INFLUENCE OF IRRELEVANT SPECIAL DISCOMFORT ON LEARNING—THE PERCENTAGE OF REPETITIONS IN TRIAL $N+1$ OF A CORRECT CONNECTION OCCURRING IN TRIALS 1 TO N

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Med'n
								One correct in trial 1									
No dis	68.5	65.4	64.2	38.0	65.9	66.0	75.8	53.7	89.0	69.4	70.1	58.2	53.8	35.8	52.6	42.7	
Dis	84.2	67.7	51.4	49.0	72.0	74.7	78.3	58.6	90.2	65.7	73.6	52.5	61.7	32.5	28.2	38.8	
Diff	—15.7	—2.3	12.8	—9.0	—6.1	—8.7	—2.5	—4.9	—1.2	3.7	—3.5	5.7	—7.9	3.3	24.4	3.9	—2.4
								One correct in trial 2 but not in trial 1									
No dis	46.2	44.4	46.8	17.1	28.1	43.6	23.7	27.8	56.7	59.2	47.1	27.3	37.8	19.1	20.9	13.8	
Dis	35.0	43.8	37.5	22.2	50.0	43.5	47.1	43.8	75.0	42.3	41.7	53.3	37.5	7.4	19.2	17.2	
Diff	11.2	0.6	9.3	—5.1	—21.9	0.1	—23.4	—16.0	—18.3	16.9	5.4	—26.0	0.3	11.7	1.7	—3.4	0.35
								One correct in trial 3 but not in trials 1 or 2									
No dis	24.2	40.9	38.6	31.4	25.7	36.0	50.0	37.1	56.5	45.9	38.2	40.0	22.5	34.1	27.1	27.0	
Dis	40.0	48.0	42.9	37.1	26.1	42.9	65.0	30.8	66.7	37.5	25.9	36.1	27.3	21.4	38.5	31.0	
Diff	—15.8	—7.1	—4.3	—5.7	—0.4	—6.9	—15.0	6.3	—10.2	8.4	12.3	3.9	—4.8	12.7	—11.4	—4.0	—4.65
								Two correct in trials 1 and 2									
No dis	83.9	85.5	84.8	73.1	85.2	85.9	91.7	89.2	96.1	86.8	90.2	86.0	85.7	36.8	63.3	78.1	
Dis	84.0	89.1	78.9	58.3	86.7	87.7	95.6	82.9	96.6	91.1	92.2	83.9	80.0	46.2	54.5	63.2	
Diff	—0.1	—3.6	5.9	14.8	1.5	—1.8	—3.9	6.3	—0.5	—4.3	—2.0	2.1	5.7	—9.4	8.8	14.9	0.7
								Two correct in trials 1 and 3 or 2 and 3									
No dis	61.5	75.0	76.2	83.3	72.7	76.5	90.0	50.0	88.8	76.0	60.0	85.7	70.6	55.6	75.5	100.0	
Dis	75.0	76.5	76.9	60.0	66.7	90.0	71.4	76.9	88.2	76.9	90.9	73.3	50.0	100.0	20.0	57.1	
Diff	—13.5	—1.5	—0.7	23.3	6.0	—13.5	18.6	—26.9	0.6	—0.9	—30.9	12.4	20.6	—44.4	55.5	42.9	0.0
								Three correct									
No dis	92.3	96.6	96.4	85.0	88.4	96.3	100.0	88.1	98.7	91.5	92.5	98.0	94.4	85.7	94.4	80.0	
Dis	89.0	89.7	93.1	100.0	92.2	91.8	94.3	96.4	98.2	92.7	93.1	92.6	95.7	100.0	83.3	90.9	
Diff	3.3	6.9	3.3	—15.0	—3.8	4.5	5.7	8.3	0.5	—1.2	—0.6	5.4	—1.3	—14.3	11.1	—10.9	19
Average															—0.7±0.6 (P.E.)		

and learning without discomfort as follows. We list the correct responses in trial 1 under each condition and find what percentage of them were repeated in trial 2. We also list the correct responses occurring for the first time in trial 2 (or 3) and find what percentage of them were repeated in trial 3 (or 4). We also list the responses that were correct in both trial 1 and trial 2 and find what percentage of them were repeated in trial 3. And so on for all other combinations of correct responses.

We make the comparisons separately for each of the 16 individuals with the results shown in Table 2. The strengthening by the reward is almost exactly the same with as without discomfort. There are 50 cases where it is greater with discomfort, and 46 cases where it is greater without discomfort. The average of the six medians of differences is —0.7 with a P.E. of ±0.6.

The median difference for the learning as shown by the repetitions in trial 2 of connections rewarded as correct in trial 1 is —2.4. This represents the success in remembering pairs from hearing the experimenter read them and the confirming influence of the announcements of "Right" in trial 1, and so covers roughly the first third of the period when the discomfort was least. The median difference for the learning as shown by the repetitions in trial 4 of connections rewarded in trial 3 but not in trial 1 or 2 is —4.65. This covers roughly the last four minutes of the period. What little difference there is is thus in favor of the discomfort over the ordinary condition, and of the later and greater discomfort over the earlier.

The same lack of interference with learning from irrelevant discomfort appears in the experiment of Tolman, Bretnall, and Hall, in which learning a series of choices, each of one spot out of two, was nearly equally rapid whether a sound or a sharp shock informed the learner whether his choice was right or wrong.

Doubtless, lengthening the period from 9 to 18 or 27 or 54 minutes and increasing the intensity of the pain would at some point cause interference of some sort. Our results hold only for the specified time and intensity. There is, however, a clear discomfort from holding one's arm out even for a couple of minutes, and a clear relief when the shift to ordinary conditions is made. But this does not influence learning. Theoretically, one should not assume that discomfort acts unfavorably in a continuous gradient beginning at small intensities. Practically, one should not expect much in the way of better learning from the reduction of minor aches, pains, uncomfortable postures, and the like.

A CONDITIONED RESPONSE OF TWO ESCAPE REFLEX SYSTEMS OF THE GUINEA PIG AND THE SIGNIFICANCE OF THE STUDY FOR COMPARATIVE WORK

W T JAMES

An experimental procedure that would show functionally how refinement of neural structure has aided the various animal species in adjusting to environment, as well as how in the course of this refinement the relation between the cortex and lower cord systems has changed, would be of particular advantage to the experimental physiologist and psychologist The neurologists have been able to indicate structurally the growth and expansion of the nervous system from a primitive neural tube to the highly developed brain and cord system of the vertebrates. The experimental physiologists, however, and for the most part psychologists, have assumed what this refinement of structure means for the animal in the process of adjustment They have not been able to show specifically just what changes in behavior and adjustment have paralleled a refinement of and addition to neural structure They have, it is true, been able to do this to some extent in man, but not until the conditioned-reflex method was used were they able to get at the minute changes in adjustment that go with definite changes in neural structure in the lower animals The method has been used mainly in the analysis of the cortical mechanisms of the dog (5), using either the salivary reflex, or the motor defense reflex (1) as the unconditioned one This salivary and motor reflex has been modified to respond to various stimuli which were originally unmeaningful to the animal, and from this modified performance analysis of the cortex has been made The use of the method in comparing nervous systems of different stages of refinement and development has not been emphasized to any great extent It has been suggested, however, by the studies of Liddell and Anderson (3), who compared the rate of development of the conditioned defense reflex of the foreleg in the sheep, rabbit, goat, and pig, by Upton (7), who used the method in studying the guinea pig's ability to hear pure tones and by Wever (8), who used conditioned breathing to study the upper limit of hearing in the cat One of the most significant things, comparatively speaking, indicated by Anderson and Liddell is that the conditioned defense response develops in the rabbit after twenty to thirty applications of the new stimulus, after six applications in the sheep, and after from one to two in the pig The same defense response is conditioned in the dog after about six applications of the new stimulus These studies suggest the possibilities of the method in comparing the cortical mechanisms of different stages of refinement There is another phase of the problem, however, which has to do with the relation between this developed cortex

and the lower cord systems Is the conditioned-reflex method adequate to indicate just what this evolutionary development has meant for the cortex and its relation to the lower cord systems? We devised two experiments to see whether or not this method could be used to show this relation These experiments deal with two escape response mechanisms of the guinea pig In one of the experiments we studied the relation between the cortex and the total escape reflex system of the cord, that involving all legs and leg segments, and in the other we studied the relation between the cortex and one segment of this total escape mechanism, that to only one leg. Experiment 1 deals with the first problem and Experiment 2 deals with the second problem Two male guinea pigs of the same litter were used, one in each experiment

Experiment 1.

The first experiment was devised to condition the defense reflex of the right foreleg of the guinea pig to the sound of a metronome In the experiment the animal was isolated in a small room and confined by harness on a table. The harness was attached around the body of the animal and then fastened to a beam 8 inches above the table surface The animal was allowed freedom of movement within a radius of about 8 inches Wire electrodes were buckled on a shaved portion of the right foreleg to apply an electric shock The procedure followed throughout the experiment was to sound the metronome (rate 160) for 5 seconds and then give the shock. From an adjoining room the experimenter could observe the behavior of the animal through a periscope. The metronome was started and stopped by means of an electrical lever.

Results of Experiment 1 During the first part of the experiment the animal remained in a crouched position and would move only when shocked The response then consisted of rhythmical running movements with the feet sliding on the surface of the table After the shock had been applied the animal would again take the crouched position The first definite response to the metronome occurred on the one-hundredth application In this case the animal raised up on the feet as if "set" to run, and remained in this position until the shock was given This postural adjustment occurred only 9 times between stimulus 100 and stimulus 197 After stimulus 197 the shift in posture was confined to the fore part of the body and when the shock was given the animal raised the foreleg. This unconditioned response of the right foreleg, when the shock was given, continued through stimulus 260, after which the true conditioned response occurred What we call the true conditioned response was the raise of the leg when the signal was given, before the application of the shock This conditioned response was at first unstable, but after stimulus 350 it appeared in 70% of the cases.

We observe that a large number of applications of the new stimulus are required to build up a conditioned escape response of the right foreleg in the guinea pig The unconditioned response at first involved the total escape mechanism of the animal, namely, running As the experiment progressed, however, the unconditioned response was next limited to the forelegs, and, finally, the conditioned flexion of the right leg appeared on the 261st stimulus We may assume that, as the response was limited to the fore part of the body, inhibition developed in the cord system below the segments involved in the conditioned response of the foreleg From the number of applications of the stimulus necessary to limit the response to the foreleg and for the appearance of the conditioned behavior, and, since the same response occurs with relatively few applications of the stimulus in the dog, sheep, and pig, we may assume that this offered a difficult task for the nervous system of this animal

EXPERIMENT 2.

In this experiment we made a study of the conditioned escape response involving the total escape mechanism The apparatus consisted of a box made of two small rooms (each room 1 foot square) with an elevating door between them An electric grill was placed on the floor of one side of the box (room *A*) so that a shock could be applied to the feet of the animal eliciting the running reflex When the shock was applied the door between the two rooms was opened and the animal allowed to escape into the other side of the box (room *B*) As in the above experiment, a metronome (rate 160) was used as a signal The procedure was to sound the metronome for 5 seconds, then apply the shock and at the same time open the door allowing the animal to run into *B* Since the top of the box was covered with a 2-inch mesh wire, we could observe the behavior of the animal from the experimental room by the use of the periscope.

Results of Experiment 2 At first, of course, the animal would not move until shocked, and when shocked it made two circular runs around room *A* before finding an escape. On the immediately succeeding applications of the stimuli the guinea pig ran directly to the door when shocked The conditioned response to the metronome appeared on the twelfth application, when the animal ran to the door as soon as the metronome started Following this conditioned running the pig would take a "set" on the feet, "as if ready to run," and maintain this posture during the 5 seconds, then run for the door as soon as it opened This postural adjustment, with delay of running, appeared on the fortieth application of the signal

DISCUSSION OF THE EXPERIMENTS

The difference in number of applications of the new stimulus required to condition these two escape responses indicates a difference in structural

and functional relation between them and the cortex In Experiment 1 we were dealing with a short reflex system (6, p 157), but the excitation at first irradiated throughout the total escape mechanism. The response was limited to the forelegs after a large number of repetitions of the metronome and shock During this time we may suppose that inhibition had developed in the cord system below the two segments involved in the front leg movements The separation of this one leg segment from the total integrated activity of the escape mechanism was undoubtedly a difficult task for the nervous system of the guinea pig, since the same behavior occurs with few applications of the stimulus in the animals indicated above This difference in appearance of conditioned adjustment between these animals is probably due to a difference in development and refinement of neural structure In Experiment 2 we observed that the total escape mechanism could be conditioned with relatively few applications of the stimulus In this case we were dealing with a more natural response. The guinea pig escapes from all dangerous and painful objects by running. The response here is generalized in the sense that it involves the total integrated reflex system of the cord This total integrated escape system undoubtedly has a closer functional relation with the cortex than any one segment of the total system From this we may assume that the development of the cord and cerebrospinal tract system is adequate to signal the total running reflex but has not developed to the point where it signals the one segment without difficulty. This fact is in correlation with that of von Lenhossék (4), who found that the relation of the area of the cerebrospinal tract to the total cross-area of the spinal cord is low for the guinea pig in comparison to that in the mouse, rabbit, cat, and man.

According to the prevailing theory, responses of the low-developed nervous system are generalized, that is, irradiation of excitation leads to an adjustment involving the total mechanism no matter in what part of the system the excitation arises (2) In the course of development the segments have become more and more subject to differentiated responses Since in the above experiments we indicate the functional relation between the cortex and the total, as well as segmental responses of the escape mechanism, the conditioned-reflex method would seem to offer a functional approach to specific changes in adjustment that are due to evolutionary development of the nervous system By this method the changes in functional relation between the brain and the cord systems may be traced from the smooth-brained animal to the more highly developed brain of higher animals and man, as well as analytical and synthetic ability of the cortical mechanisms

REFERENCES

1 BERETOV, J S The fundamental processes in the cortex of the cerebral hemispheres *Brain,* 1924, **47,** 109-148
2 HERRICK, C. J, & COGHILL, G E The development of the reflex mechanism in Amblystoma *J Comp Neur,* 1925, **26,** 65-85

3 LIDDELL, H S, & ANDERSON, O D Comparative study of the conditioned motor reflex in the rabbit, sheep, goat and pig *Amer. J Physiol*, 1931, 97, 539

4 VON LENHOSSÉK, M Der feinere Bau des Nervensystems in Lichte neuester Forschungen Eine algemeine Betrachtung der Strukturprinzipien des Nervensystems, nebst einer Darstellung des feineren Baus des Ruckenmarkes (2nd ed, rev.) Berlin Kornfeld, 1895 Pp 416

5 PAVLOV, I P Conditioned reflexes an investigation of the physiological activity of the cerebral cortex (Trans & ed by G V Anrep) London Oxford Univ Press, 1927. Pp xvi + 430

6 SHERRINGTON, C S The integrative action of the nervous system. London Constable, New York. Scribner's, 1906. Pp 411

7. UPTON, M The auditory sensitivity of the guinea pig. *Amer J. Psychol*, 1929, **41**, 412-421.

8 WEVER, E G The upper limit of hearing in the cat *J Comp. Psychol*, 1930, **10**, 221-233.

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THE GENETIC DEVELOPMENT OF THE KITTEN'S CAPACITY TO RIGHT ITSELF IN THE AIR WHEN FALLING

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The present note reports the results of a series of preliminary experiments on the genetic development of what has been called the righting reflex in cats The study was undertaken in an effort to analyze the early growth of a particular form of receptor control of behavior which in its adult form had been attributed by physiologists, at least in part, to past experience and even possibly to consciousness

The ability of adult cats and some other mammals to right themselves in air in a drop from an upside-down position has long been known to casual observation The first scientific analysis of this phenomenon seems to have been made by E J. Marey (9) [1] This investigator, by the use of an early form of serial-picture camera, was able to demonstrate the fact that the rotation of the fore and hind parts of the cat's body takes place at different temporal stages during a fall through air. At first the

[1]The development and scientific use of Marey's camera is interesting in its own right For a detailed description see Marey's own historical paper (11) Four series of Marey's original pictures showing falling cats are given in the 1894 paper (9, pp 715-717) These same pictures are also reproduced in *Nature* (10, p 80) Unpublished pictures of the falling cat taken by Marey are in existence, for Magnus speaks of having seen some of them through the courtesy of Professor Weiss of Konigsberg (7, p. 222)

twist begins in the fore part of the body When this turn amounts to 180 degrees the rear part of the animal begins to turn (9, p 716) Parenthetically it may be added that a more recent study seems to suggest that the turn begins more nearly at 90 than at 180 degrees. The physical and mathematical, as contrasted with the physiological, explanation of this phenomenon that is offered by Marey is that the cat uses the inertia of its own mass to right itself (10, p 81) M Camis (1, pp. 1-5) has recently shown that this conclusion was vigorously attacked on mathematical grounds as contrary to the theorem of the moments of quantities of motion This objection was satisfactorily met in terms of theoretical mechanics by Guyou (5) and Lévy (6).

In 1916 Muller and Weed reported a series of experiments on the physiological basis of this phenomenon in the adult cat (12) In their experiments animals were released from a horizontal position with backs parallel to the floor An effort was made to avoid imparting to the animals any rotary impulse on release by the hands, a performance, incidentally, which motion pictures of the present writer's efforts showed to be almost impossible, for him at any rate They found that all normal animals were able to turn in a fall of one foot. Some could turn in a fall of six inches Blinded animals turned almost as well as normal animals, although they did not land so well, "seemingly because of their ignorance of the height of the fall" Complete removal of semicircular canals on one side in otherwise normal cats interfered very little with the righting reaction Such a unilateral operation merely induced certain tonus changes and led to the need of a longer fall in order that complete righting might occur When both internal ears were completely destroyed, animals still turned in air and landed on their feet. This was found in every animal so treated. These investigators report, however, that if animals in which one or both of the semicircular systems had been destroyed were blinded by placing a hood over the eyes no rotation at all took place on falling. Unilateral ablation of the motor cortex did not interfere with rotation in the air Most animals with bilateral motor ablation also turned One animal in this series, it is reported, showed itself able to turn only the front part of the body, the posterior part of the body not participating in the twist necessary for complete rotation This observation is especially interesting in light of the genetic development reported below Muller and Weed further report that complete removal of the hemispheres led to a full loss of the ability to turn in air The possibility of the function of consciousness in this righting process is therefore raised as a query by these authors. They concluded that the falling reflex is probably an acquired form of protective mechanism dependent on influences from the semicircular canals and from the eyes, mediated largely, if not entirely, through the cerebral cortex.

R Magnus (7, 8), J G Dusser de Barenne (4), and others of the Utrecht school have also studied this phenomenon in relation to its receptor-central-nervous-system mechanism In summarizing this work Magnus suggests that the ability to turn in air so as to land on all fours is a function of intact labyrinths The typical course of falling in air in a normal cat, as determined from pictures which Magnus himself has taken and reproduced, involves a series of stages including the following First, the animal falls for a short distance through the air back down The head then begins to turn while the rest of the body remains undisturbed When the head has turned through 90 degrees the thorax begins to turn, the hind portion of the body still remaining immobile Soon, however, this rear portion begins to turn, and finally the body is completely re-oriented, so that the animal lands on all four legs This landing is made possible because the tonus and extension of the limbs have undergone change, as if in preparation for this landing, during the latter part of the fall. In an analysis of this complex act Magnus suggests that the reaction of the receptors of the labyrinth is essential in initiating the head turn and that this turning then initiates tonic neck reflexes which lead to complete body turning These students also report the central-nervous-system basis of the response as essentially the same as that indicated by Muller and Weed Camis (1, p 264), however, points out that Muller and Weed make a significant contribution to the phenomenon over and above that of Magnus in that they deal with the "vicarious" function of the eyes in the righting reflex

In the preliminary experiments reported here an effort was made to study the genetic development of this complex, adaptive act A device was constructed by means of which kittens of various sizes could be supported upside down by their four legs without causing them apparent discomfort By pressing levers the animals could be released and allowed to fall one meter onto a soft feather pillow A series of fourteen kittens was used in these experiments Eight of these fourteen were sufficiently studied to give significant results Typically, each kitten was dropped three times each day beginning a day or two after birth Brief written protocols describing each fall were taken In the case of animals that did not completely turn in falling, the time required for them to regain a standing position after landing on the pillow was in many instances taken by the use of a stop-watch At all crucial points in the experiment motion-picture records, photographed at approximately 60 exposures per second, were taken of the falls. Because of illness in certain of the kittens studied, it seems unwise to give here norms in regard to the average times for the development of particular aspects of righting behavior The author feels that qualitatively, however, the general picture of the development of this response may be described as follows

1 At first all kittens fall without giving any indication of turning. They land upside down with all four legs in the air. This often continues for a number of days after the eyes are open, but some indication of head turning is secured in some kittens before the eyes are open.

2 There is a gradual decrease in the time required for righting movements on the pillow after falls in which no turn occurs. This decrease in time is roughly related to the increasing age of the kitten observed.

3 Evidence of turning in air seems to begin in the neck region; that is, during the period when the moving-picture records show the first indication of turning many kittens land with the head region partially or even almost fully righted, but with the caudal region still unturned. This is apparently not universal, but the noted exceptions may have been the result of unequal release by the apparatus of the four legs.

4 Evidence of turning in the air may be apparent on one day and not on the next day in the same kitten, but in general the increasing ability to turn in air is a function of increasing age.

5 Full righting appears first as if by chance and then gradually becomes more and more regular. At six weeks, when most of the experiments were concluded, righting was well established in most of the kittens studied, even though some of them had been for some time suffering from an infection. In no case in this length of time had the righting reaction reached the invariable condition which is characteristic of the healthy adult cat.

Further detailed experiments on the development of this capacity in a more normal group of kittens and on the receptor control of the response are planned. The writer wishes to express his gratitude to Miss Margaret E. Keller for her assistance in conducting the preliminary experiments summarized above.

Theoretically, these genetic results are interesting, not only because they substantiate the speculations concerning development of this response made by observers who had studied only the adult phenomenon, but also because they point to significant genetic relationships. It has been noted above that the physiological processes underlying the righting reflex in the adult animal are complex. Certain specific ablations of receptors or of particular parts of the central nervous system seem to modify and eventually to abolish entirely the reaction. It is interesting to note that the partial loss of the ability is not, in all cases at any rate, characterized by a general blunting of the total function. This loss is rather a specific return to a form of activity which our observations show to be characteristic of an earlier genetic stage in the growth of the typical adult reaction. It is interesting also to note that the present observations show that the turning of the head which has been demonstrated as physiologically first in the perfected adult act is also genetically first. The study of the genetic development of this function, therefore, seems to offer evidence con-

cerning an intimate relationship between the time sequence in the performance of the response in the adult cat and in the genetic development of the act. Further analysis of this process of righting in air may well show that its development is in a continuum with the development of the righting reflex in an animal which is in contact with water or a solid surface The records of the present experiment show that in part antecedent to and in part concomitant with perfection in turning in air there is an increasing perfection in the act of turning on a solid surface, as measured by the time required for this act after the kitten has landed in an upside-down position The development of righting ability on a solid surface has been shown to originate in the prenatal life of the cat by a number of investigators (13, 14, 3, 2)

The discovered relationship between the genetic development of partial acts making up the total response and of the time relations in component behavioral acts of the adult cat points to a developmental relationship which may play a significant part in understanding the growth of other types of behavior which are now considered as saltatory maturations The complex time relationships disclosed in the adult performance and in the genetic development of this act may therefore indicate something of one form of analysis which may prove fruitful in an understanding of other complex behavior patterns in the adult

REFERENCES

1. CAMIS, M The physiology of the vestibular apparatus (Trans by R S Creed) Oxford: Clarendon Press, 1930 Pp xiv+310
2. CARMICHAEL, L. The origin and prenatal growth of behavior In *A Handbook of child psychology*, 2nd ed, ed by C. Murchison Worcester, Mass Clark Univ Press, London Oxford Univ Press, 1933 Pp 31-159
3. CORONIOS, J D The prenatal development of behavior in the cat *Genet Psychol. Monog*, 1933, **14**, 283-386
4. DUSSER DE BARENNE, J. G, & MAGNUS, R Beitrage zum Problem der Körperstellung. III Mitteilung Die Stellreflexe bei der grosshirnlosen Katze und dem grosshirnlosen Hunde *Pflug Arch f. d ges Physiol*, 1920, **180**, 75-89.
5. GUYOU, — Mécanique animale Note relative à la communication de M Marey *C r Acad. Sci*, 1894, **119**, 717-718
6. LÉVY, M Mécanique Observations sur le principe des aires *C r Acad Sci*, 1894, **119**, 718-721.
7. MAGNUS, R. Wie sich die fallende Katze in der Luft umdreht *Arch Néerl de Physiol*, 1922, **7**, 218-222
8. ——— Korperstellung Berlin. Springer, 1924 Pp xiii+740
9. MAREY, E. J Mécanique animale Des mouvements que certains animaux exécutent pour retomber sur leurs pieds, lorsqu'ils sont précipités d'un lieu elevé *C r Acad Sci*, 1894, **119**, 714-717
10. ——— Photographs of a tumbling cat *Nature*, 1894, **51**, 80-81

11 ——— The history of chronophotography. In *Ann Rep Bd Regents, Smithsonian Instit, 1901* Washington, Govt. Printing Off, 1902 Pp. 317-340

12 MULLER, H R, & WEED, L N Notes on the falling reflex in cats *Amer. J Physiol*, 1916, 40, 373-379.

13 WINDLE, W F, & FISH, M W The development of the vestibular righting reflex in the cat *J Comp. Neurol.*, 1932, 54, 85-96

14 WINDLE, W F, & GRIFFIN, A M. Observations on embryonic and fetal movements of the cat *J Comp Neurol*, 1931, 52, 149-188

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THE EFFECT OF AUDITORY STIMULATION UPON THE MAZE BEHAVIOR OF THE WHITE RAT

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The present experiment deals with certain effects of auditory stimulation on the behavior of the white rat on an elevated maze. A number of studies have dealt with certain aspects of the problem of the relationship between audition and the control of behavior Barber and Hunter (1, 4) have shown that the white rat is capable of localizing noise Thuma (13) used a T-shaped discrimination box and reports that, while the white rat develops responses to tones only after a large number of trials, the animal can be brought to make locomotor responses to tones if a criterion lower than that used by Hunter be accepted. Muenzinger and Gentry (9), using a Y-shaped discrimination apparatus, find that the white rat makes discriminatory responses to diffuse and directed tones with far fewer trials than Thuma found necessary with his experimental arrangements They suggest that the difference in the number of trials necessary in these studies is a function of the apparatus Trueblood (14) was unable to account for certain behavioral disturbances in some animals following rotation of the tunnel maze without assuming effective auditory stimulation Shepard (12) found that rats were influenced in their maze behavior by stimulation, or changes in stimulation, received from the floor over which they traveled and suggests that in all probability this stimulation was of an "auditory character" Patrick and Anderson (11) state that a sudden change in incidental stimuli of sound and light will cause errors in succeeding trials even though the maze had been correctly learned under the old conditions. Morey (8) reports the facilitating effect of sound upon the rat's activity in the water maze Dennis (3) suggests that auditory stimuli may play a part in the formation of the maze habit The studies just summarized indicate that the maze behavior of the white rat may be influenced by auditory stimulation. The negative results of Casper (2) secured under special

conditions do not seem fully relevant here The aim of the present experiment is to study in a quantitative manner one specific form of auditory *stimulation in relation to the development of the maze habit in the white* rat

An elevated maze was used in the present experiment It stood 25 inches above the floor and was constructed of pine sections, 2 inches by ⅞ inch, each section 2 or more feet distant from adjacent segments The true pathway measured 40 feet, the overall length measured 70 feet Critical turns from the start to the food-box were left, right, left, left, left, right, right, right. In order to avoid incidental sound as far as possible the experiment was carried on from 11 30 P M to 1 00 A.M On each side of the maze and 3 feet therefrom a pressed-wood sound board was placed The room was lighted with 12 25-watt electric bulbs regularly spaced and shielded by metal reflectors, an arrangement which as measured by the Westinghouse Foot Candle Meter gave an approximately equal illumination at all points on the maze Three low frequency buzzers, connected in series, and mounted on an elevated 25-inch standard to the left of the maze, supplied the sound stimuli

Twenty-three male white rats of Wistar stock, four and a half months of age at the beginning of the experiment, were used They were trained for eight days in groups of four for one-half hour each evening The animals were placed first in groups, and, on the fifth day, individually upon the training straightaway set up in the maze room This straightaway was lengthened frequently until it approached the length of the true pathway of the actual maze The rats were fed each evening individually upon the food platform The daily ration for each animal consisted of six grams of McCullom's diet, fed as a dry meal Fresh lettuce and crumbs of dog biscuit moistened in cod-liver oil were also given daily

The rats were divided into two groups The group learning without buzzer stimulation consisted of 13 animals Three consecutive perfect trials were taken as the criterion of learning. The animals were then given a test series wherein sound was introduced The second group learning the maze with buzzer stimulation from the left consisted of 10 animals They were given a test series with sound shifted to the right, the sound source occupying a similar position with respect to the sounding board and the maze as it had on the left The test series was continued until the rats had approximated the running-time exhibited in the training series Five additional animals in this group were submitted to a test series in which buzzer stimulation, *instead of being shifted from left to right*, was omitted altogether This series was also continued until the running-time under the altered conditions approximated the running-time under the original conditions During the actual experimentation period the operator retired to a shielded celotex cubicle equipped with a one-way vision screen Records were made of the following items

1. The time the animals spent on the maze, total maze time
2. The actual time spent in running the maze.
3. The errors made in order of their appearance
4. The time required to traverse specific sections of the true pathway with respect to *the direction toward or away from the sound source*

RESULTS

1. The effect of auditory stimulation on the maze behavior of the rat may be seen initially in the effect of introduced sound upon the performances of animals trained without sound

A. The mean number of *trials required for learning without sound* was 21 5 In the test series (with sound introduced) an average of 12 8 additional trials, 60% of the original number of trials, was required for the animals to reach the original level of performance

B The average maze time with sound introduced after learning was 40% greater than the average maze time for the original learning, as computed from a comparison *of the final two training trials with the two* test trials The average running-time in the test series was 46% greater

2 The effect of auditory stimulation on maze behavior may be further seen in a comparison of the performances of animals learning when sound was constant with their performances when the sound source was shifted. All animals were disturbed by the change The average number of learning trials was *10.5* The average score in time of the animals in learning was 152 seconds per trial for maze time and 99 seconds per trial for running-time. The median scores, 106 seconds maze time and 63 seconds *running-time, are, however, more representative of the group learning* with sound, for the reason that one animal required twice the average time and thus raised the mean

With the shift in buzzer position after learning, *72 7* was the median percentage of the original number of learning trials required for the animals to reach their former level of performance The average score showed 86% the original number of trials required to adapt to the sound change In terms of feet traversed in blind alleys during learning, the median animal covered 75% of this original distance in the test series before the maze performance approximated the original wherein sound stimulation had come from the left The average score of the animals in feet retraced was 87% the true pathway retraced in the training series A comparison of the final two training trials with the first two of the test series indicates that the average maze and running-times in the test series exceeded those of the *training series by 50%*

The influence of auditory stimulation on the maze behavior of these animals is still further apparent from a consideration of the character of the errors made in the test series To reach the food in the training

TABLE 1

SHOWING THE EFFECT OF SOUND FROM AN EXTRA-MAZE SOURCE AS CONTRASTED WITH ITS ABSENCE IN MAZE LEARNING

Group I

	Learning without sound					Sound introduced—test series				
	Trials	Running-time (secs.)	Maze time (secs.)	Retraced true path (ft.)	Blind distance traversed (ft.)	Trials	Running-time (secs.)	Maze time (secs.)	Retraced true path (ft.)	Blind distance traversed (ft.)
Median	20.0	110.6	193.0	117.0	103.5	12.0	32.7	67.5	12.0	19.6
Mean	21.5	131.3	201.6	116.8	136.2	12.8	27.6	81.9	15.3	20.4
Mean deviation	5.0	43.6	65.6	34.4	41.0	4.0	7.5	33.2	10.6	14.0

Group II

	Learning with sound					Sound shift—test series				
	Trials	Running-time (secs.)	Maze time (secs.)	Retraced true path (ft.)	Blind distance traversed (ft.)	Trials	Running-time (secs.)	Maze time (secs.)	Retraced true path (ft.)	Blind distance traversed (ft.)
Median	11.0	62.6	106.0	58.0	76.0	8.0	20.0	51.6	8.0	19.0
Mean	10.5	99.0	152.0	68.1	90.3	9.1	19.5	50.8	5.8	26.6
Mean deviation	2.0	40.0	44.0	26.0	37.6	3.2	6.4	32.2	4.1	21.0

series the animals had necessarily at one point to make a left turn carrying them *away* from the sound source With the shift of the sound to the right, however, this left turn now carried them *toward* the sound source Nevertheless, in the test trials, the animals continued at this point to turn *away* from the sound, consequently entering blind alleys for several trials, and thus indicating that auditory stimulation had temporarily prevailed over other modalities in influencing maze orientation

3. When, with five rats trained with sound, sound stimulation was omitted altogether in the test series, the average number of trials required to reach the former level of performance was 90% of the original number of training trials

4 Measurement of the time required by rats in the group learning with sound stimulation to traverse a specific section of the maze leading toward or away from the sound suggests that the male white rat travels approximately twice as fast toward sound as the animal travels away from it This conclusion is based upon a comparison computed from the final two training trials wherein the performance of the rat was more constant.

5. Finally, a general comparison of the performances of the two groups, those learning with sound and those learning without sound stimulation, indicates that 55% fewer trials, 55% less maze time per trial, and 56% less running-time per trial (median scores) were required by the 10 rats learning with sound than by the 13 rats learning without it The mean total maze time of the animals learning without sound was 2 5 times greater than that of the animals learning with it The mean total running-time was 2 86 times greater for the animals learning without than for those learning with sound The median scores of animals learning with sound show that the animals retraced 50% less true pathway and entered 27% fewer blind alleys than did the animals learning without sound. Animals learning the maze with sound show less disturbance, as measured in mean and median scores for time, trials, and errors, when the sound is shifted in position, than do animals learning the maze without sound when sound is introduced.

Summary

1 The maze performances of 23 male white rats were studied comparatively in an elevated-maze situation involving the presence and absence of auditory stimulation from an extra-maze source, with alterations in the position of the sound stimulus

2. The animals learning the maze with sound make 50% fewer errors, traverse 27% less distance in blind alleys, and require approximately 55% fewer trials, 56% less running-time, and 55% less maze time than animals learning without sound This confirms the statement of Patrick (10) that sound may facilitate learning

3 In the behavior disturbances shown upon the shift in position of the sound source and upon the omission of sound after training with it, the animals gave evidence of localizing sound and of using auditory cues from the extra-maze environment in orienting on an elevated maze

REFERENCES

1 BARBER, A. G The localization of sound in the white rat *J Anim Behav*, 1915, 5, 292-311

2 CASPER, B The normal sensory control of the perfected maze habit of the albino rat *Psychol. Bull*, 1933, 30, 702-703

3. DENNIS, W The sensory control of the white rat in the maze habit *J Genet Psychol*, 1929, 36, 39-50

4 HUNTER, W S Auditory sensitivity of the white rat *J Anim Behav.*, 1914, 4, 215-222

5 ——— Some notes on auditory sensitivity of the white rat *Psychobiol*, 1918, 1, 177-185

6 ——— Further data on auditory sensitivity of the white rat *Ped. Sem*, 1927, 7, 177-185

7. ——— The sensory control of the maze habit in the white rat *J. Genet Psychol.*, 1929, 36, 505-537

8. MOREY, R Dynamogenic effect of sound on the activity of rats *Psychol Bull*, 1933, 30, 588

9 MUENZINGER, K F, & GENTRY, E Tone discrimination in white rats *J Comp Psychol*, 1931, 12, 195-205

10. PATRICK, J R. The effect of emotional stimuli on the activity level of the white rat *J Comp Psychol*, 1931, 12, 357-363.

11 PATRICK, J. R, & ANDERSON, A C The effect of incidental stimuli on maze learning with the white rat *J Comp. Psychol*, 1930, 10, 295-307

12 SHEPARD, J F An unexpected cue in maze learning *Psychol Bull*, 1929, 26, 164-165

13. THUMA, B D Response of the white rat to tonal stimuli. *J. Comp Psychol*, 1932, 13, 57-86.

14 TRUEBLOOD C. K The behavior of the white rat in a rotated tunnel maze *J Genet Psychol*, 1932, 40, 330-350

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FURTHER NOTES ON PUNISHMENT AND REWARD

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This study was designed to cast light on two points In the first place, I wished to see if the lack of agreement between Thorndike's (2, Chap. XI) conclusions and some of my results (1) were due to differences in method. In the second place, I wished to determine if the same explanation which accounted for any anomalous results in my data (whenever such anomalous results did appear) would account for similarly anomalous results in Thorndike's data

The lack of agreement mentioned above is briefly this In his Spanish-vocabulary experiments Thorndike found that the oral announcement of "wrong" after an error did not weaken the underlying connection but slightly strengthened it. In my experiments on motor learning, such oral announcement of "wrong" did weaken the underlying connection quite perceptibly[1]

It seemed quite probable that this discrepancy was due to the differences in the experimental methods Thorndike's conclusions are based largely on experiments in learning the English equivalents of 200 Spanish words. In his experiments the test of the influence of the reward or punishment came 24 hours after that reward or punishment had been applied. Moreover, during that interval the subject had made choices and had been punished or rewarded in connection with 199 other similar words. In my experiments the test of the influence of the punishment or the reward came within a few seconds of its application and during that interval nothing of a distracting nature was introduced.

In order to see if such differences would account for the discrepancies in the results I attempted to duplicate Thorndike's technique in the respects detailed above

The second of the two purposes was the more important. In the experiment on learning to hit the bull's eye of a target, I had found that, while an oral announcement of "wrong" weakened the tendency, the announcement of "wrong" by means of signals of lights did not weaken but slightly strengthened the connection These latter results are in line with Thorndike's conclusions I found, however, that a meaningless (or neutral) flash of lights strengthened the connection even more than did a flash of lights meaning "wrong" This was taken to indicate that the flash of the lights in itself strengthened the connection but the addition of "punishing" information to that flash reduced the strengthening effect Con-

[1]On the other hand, when the announcement was made by some signals of lights the connection was not weakened but strengthened (as in the case of Thorndike's experiments)

sequently, it seemed not unlikely that in Thorndike's experiments the mere fact of saying *something*, irrespective of the meaning conveyed, might cause some strengthening of the connection

A group of 29 summer-school students were given the vocabulary test of the American Council Beta Spanish Test, Form A. This test was in multiple-choice form, the subject underlining the English word he judged to be the equivalent of the Spanish word On the following day the subjects were given the same test modified so as to provide information regarding the correctness of the second day's choice *The directions and a reproduction of one page of the second day's tests are given* In the reproduction *some of the strips have been pulled off*

> *Directions* In each line select the English word or phrase which most nearly corresponds with the Spanish word at the left Pull off the perforated strip which you find under that

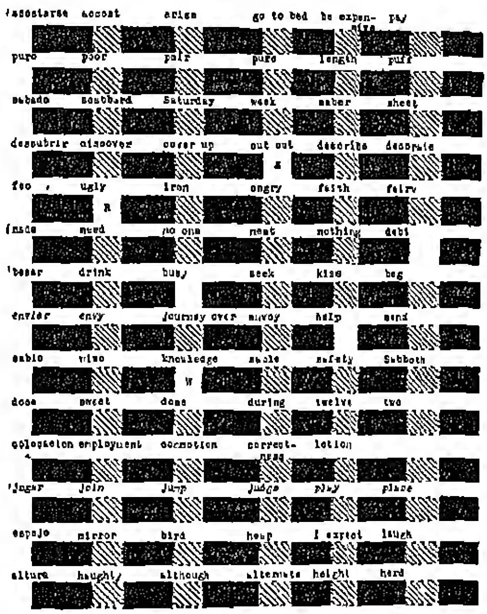

FIGURE 1

SAMPLE

Solid black indicates a portion of the strip that is pasted down to the test paper.

Hatching indicates a portion of the strip that is not pasted down and is partially detached from the rest of the strip by means of perforations.

A blank space indicates that the portion not pasted *down has been torn off.*

> word or phrase. Pull off only one strip in each line Beneath some of the perforated strips you will find the letter "R" This *will mean that you have chosen the right word* *Beneath others* you will find the letter "W" which means that you have chosen a wrong word. Beneath most of the strips you will not find any letter In that case you will not know whether you are right or wrong. *Remember it does not mean that you are wrong, but merely that you cannot tell.* Underneath still other strips you may find a blurred letter like this & This comes from the correction of a mistake It should have been left blank by the typist It means exactly the same as a blank, namely, that you just don't know whether it is right or wrong.

After this page of directions and the sample, there followed 73 Spanish words each with its accompanying choices of English words Under each line was pasted a strip of paper with five sections marked off by perforations These sections had no paste on them and could easily be detached The letters referred to in the directions were found under about 60% of these detachable sections. The significance of the letters will be clear from the directions

The procedure on the third day was exactly the same as that on the *first* day.

The technique outlined above differs from that employed by Thorndike chiefly in the following particulars

Thorndike's experiments	Present experiment
1 "Right" and "Wrong" announced orally by experimenter	Subject determines his success or failure upon the removal of the slip
2 Information is given after every choice.	Information is given after only 60% of the choices.
3. One subject tested at a time	Twenty or thirty subjects tested at a time
4 Two hundred choices involved	Seventy three choices involved

These differences may be important. The use of strips makes possible a more constant control of conditions, since inflections in the voice, lack of assurance, hesitations, hurried corrections, etc, do not enter in It is quite possible that these factors, which would be extremely difficult to eliminate in the oral situation, may be rather important. Moreover, it would be difficult to prove that such variations would not be in the nature of a constant error tending to occur more in the case of "wrong" than "right" or vice versa On the other hand, the use of strips makes the problem somewhat less natural and may distract the subject's attention

The use of sporadic effects instead of the regular application used by Thorndike may make some difference. The application of an effect after every choice presents a double type of information The subject is confronted with "wrong instead of right" rather than "wrong instead of nothing."

Such a modification on my part seemed unavoidable in comparing the influence of "right" and of "wrong" If we are to measure the influence of "knowing that a response is right," it seems that we must compare the influence of "a stimulus indicating success," and this latter is very different from a "stimulus meaning failure" No way of thus providing a control seems to offer itself except that of leaving a substantial number of choices unrewarded and unpunished

The third difference in technique is not likely to be important, except perhaps that there is, in the group method, some opportunity of going back over the choices and trying to memorize them.[2]

The influence of length will be discussed in detail later.

From the above tests we can determine for each Spanish word (*a*) which English word was selected on the second day, (*b*) what information the subject received regarding that selection, and (*c*) whether or not that choice persisted (i e, whether or not the same English word was selected on the third day) It will be noticed that in these determinations we pay no attention to the words selected on the first day.

From these data we are able to select all those second day's choices *which were followed by no information and to compute what percentage* of those choices persisted to the third day. Similarly we can compute the percentage of persistence among the words followed by the other three conditions respectively (Table 1)

From the above figures it seems quite clear that (*a*) a connection is more likely to persist if followed by "right" than if followed by nothing at all,

TABLE 1

NUMBER AND PERCENTAGE OF ALL CHOICES PERSISTING WHEN FOLLOWED BY DIFFERENT CONDITIONS

Conditions	Total no of words followed by a *given condition*	Number *persisting*	Percentage *persisting*
Blank (no information)	845	469	56 ± 1 0
Nonsense symbol (no information)	412	239	58 ± 1.6
W (wrong)	406	178	44 ± 1 7
R (right)	487	376	77 ± 1 3
Right minus blank			21 ± 1 6
Blank minus wrong			12 ± 2 0
Right minus nonsense symbol			19 ± 2 1
Nonsense symbol minus wrong			14 ± 2 3

[2]From a casual discussion of these results with Professor Thorndike, I find that he attaches great importance to this possibility of "drill" in accounting for any discrepancy in our results The point will, of course, be subjected to an experimental check In the meantime, however, I should point out that this possibility is present to some extent in all experiments.

and (*b*) that a connection is less likely to persist if followed by "wrong" than if followed by nothing at all If we compare the influences of "right" and of "wrong" to the influence of the nonsense symbol we notice (*c*) that the weakening influence of "wrong" (14%) is not greatly different from the strengthening influence of "right" (19%), the difference being only 5 ± 3 1 This latter point is not presented as final, however, for two reasons In the first place, the strengthening influence of the nonsense symbol (58%) does not seem to be significantly different from the influence of a blank (56%) In the second place, it is difficult to say that a change from 58% to 77% is the same as a change from 58% to (say) 39%

The discrepancy between these results and those reported by Thorndike could, of course, be due either to the differences in administering or to the difference in the method of computing the results As mentioned above, Thorndike had nothing corresponding to our "blanks" by which he could determine how much chance a connection had of persisting when it was neither rewarded nor punished. In order to make such a determination Thorndike used pure chance as a base line With five English words to choose from, the subject would select the same word over again by pure chance in 20% of the cases. To do away with connections which were very strong at the outset, he used only those words which did not persist from the first to the second trial In so doing he reasoned that, if there were initially a strong connection between any Spanish word and an English word, that English word would be selected on the first test, and, conversely, that any word selected on the second day but not on the first had only a one to four chance of persisting unless something were done to it[8]

In our subsequent discussions those choices which persisted from the first to the second day will be called "strong" connections Those connections which appeared for the first time (i.e, which supplanted a previous connection) on the second day we will call "weak" connections Thus Thorndike's computations were confined to weak connections (as here defined).

When our data were reworked using weak connections only the facts shown in Table 2 appear

From these results two facts emerge (*a*) There is no evidence that a choice made on the second day but not on the first has only a 1:4 chance of persisting to the third day; it seems to have a little better than a 1:2 chance of persisting (*b*) Punishment, when compared to the influence

[8]Thorndike attempted to check up on this method of reasoning by using only choices which first appeared on the third and fourth trials (See 2, pp 283-284.) But practically all the data from the vocabulary-learning experiments depend upon this sort of control.

TABLE 2

NUMBER AND PERCENTAGE OF WEAK CONNECTIONS PERSISTING TO THE THIRD DAY AFTER BEING SUBJECTED TO DIFFERENT CONDITIONS

Conditions	Total no of such choices followed by a given condition	Number persisting to the third day	Percentage persisting
Blank	282	102	36 ± 1 9
Nonsense symbol	135	47	35 ± 2 7
Wrong	144	44	30 ± 2 5
Right	158	93	59 ± 2 6

of "nothing happening" or of "a neutral stimulus (nonsense symbol) happening," seems here to have only a slight weakening influence This weakening influence, although not unassailable in view of its probable error, is, however, suggested

It should be pointed out that if we had used chance expectancy (20%) as our base line we would have concluded that punishment had a strengthening influence, since the punished connections persisted 10% more than would have been expected by chance

The fact that the persistence of weak untreated connections was 36% rather than 20% will undoubtedly call to mind the comparable experiments of Thorndike In any comparison two cautions are necessary. In the first place, there are the differences in general technique mentioned above. Secondly, there is the open question as to whether or not "pulling off a strip and finding a blank" (my control) is the same as "underlining a word and receiving no information as to success or failure" (the control to which Thorndike attempted to approximate)

In order to check against the influence of the second factor, and (partially) against the influence of length, I repeated the experiment with a modified form of the material On the first and third days the procedure *did not differ from that employed in the original experiment except that* only 44 of the test items were used

On the second day, however, the technique of pulling off strips was applied to only 29 items In the case of the other 15 items the subject indicated his choice by merely underlining the word By this means I was able to compare the influence of "underlining a word and receiving no information" *vs.* "pulling off a strip and finding a blank"

This check showed that the weak choices persisted in 57 ± 4% of the cases when they were merely underlined on the second day and in 50 ± 4% of the cases when a strip was removed and a blank discovered From this we can conclude that the influence of finding a blank differs very little from that of underlining a word and being told nothing

The fact that the persistence of weak untreated connections is greater here than in the original experiment does indicate that the length of the test may have some influence—the longer the test the less likelihood of persistence

The above fact must not be taken as established since the two tests differed in one other respect than in length It does suggest that in Thorndike's experiments, involving a much longer test, the most probable persistence of the untreated weak connections might be less than 36%. Whether or not it would be reduced to pure chance (20%) we have no means of determining from our present data, nor is it the concern of this paper We are merely concerned to show that if 20% had been used as the base line in *this* experiment a constant error of from 14% to 18% would have been introduced

We now turn to a consideration of some peculiarities in the influence of punishment on the weak connections. If the figures can be taken at their face value, the influence of punishment on the weak connections is much less than its influence on all connections taken together This apparent tendency will be clearer if we compare the influences of punishment and reward on the two types of connections which we arbitrarily call "strong" and "weak" For each type of connection I give the influence of punishment and of reward We will repeat the data for the weak connections along with the new data for the strong connections. (Table 3)

TABLE 3

NUMBER AND PERCENTAGE OF STRONG AND WEAK CONNECTIONS PERSISTING TO THE THIRD DAY AFTER DIFFERENT MODES OF TREATMENT ON THE SECOND DAY

Condition	Total no of connections (choices) followed by a given condition		Number persisting to the third day		Percentage persisting	
	Strong	Weak	Strong	Weak	Strong	Weak
Blank	563	282	367	102	65 ± 1.3	36 ± 1.9
Nonsense symbol	277	135	192	47	69 ± 1 8	35 ± 2 7
Wrong	262	144	134	44	51 ± 2 1	30 ± 2 5
Right	329	158	283	93	86 ± 1 3	59 ± 2 6

The unique influences of punishment and of reward are best given by correcting for the influence of the "blank" or of the nonsense symbol I give these corrected data for both strong and weak connections. (Table 4)

Table 5 gives the extent to which the unique influence of "right" exceeds the unique influence of "wrong" under the different conditions respectively.

TABLE 4

	Strong	Weak	All
Unique influence of reward (right minus blank)	21 ± 1.8	23 ± 3.2	21
Unique influence of punishment (blank minus wrong)	14 ± 2.5	6 ± 3.1	12
Unique influence of reward (right minus nonsense)	17 ± 2.2	24 ± 3.7	19
Unique influence of punishment (nonsense minus wrong)	18 ± 2.7	5 ± 3.7	14

TABLE 5

	Strong	Weak
Using blank as a base line	7 ± 3.7	17 ± 4.4
Using nonsense symbol as a base line	—1 ± 3.5	19 ± 5.2

Since the above differences are compounds of many other differences their unreliability is very great. However, the figures strongly suggest that in the case of weak connections reward is definitely more influential than punishment but that in the case of strong connections the influence of reward is not much different from that of punishment

This fact also may have a bearing on the interpretation of Thorndike's results, since he used only weak connections.

For the above difference in the influence of punishment there is no explanation within the data themselves The slight influence of punishment on weak connections may, however, be due to the fact that the subject has a different mind set toward a weak connection than he has toward a strong connection. It may be more disconcerting to find that a strongly entrenched opinion is erroneous than to find that an indifferent guess is not correct. In expressing a weak "hunch" our very statement often invites an answer of "No" We say, "The trouble couldn't be due to this factor, could it?" A man asked to guess how much his wife paid for some wonderful bargain is probably more relieved to know the answer, than he is chagrined to hear that he guessed too much

This satisfaction of "knowing the worst" in connection with a doubtful guess may offset the annoyance which comes from guessing wrong In the case of an estimate of which we are very sure, there is no such preliminary anxiety to be relieved Consequently, the announcement of wrong would have no strengthening effect arising from the relief from that anxiety.

We come now to the discussion of the second purpose of the investigation—the attempt to see if Thorndike's results could be explained by the

action of the medium Obviously, we can secure no information along this line since none of our computations confirm Thorndike's results Nevertheless, in the case of the weak connections, where the influence of punishment is apparently much less than that of reward, I would have expected the medium (the nonsense symbol) to occupy a position approximately midway between punishment and reward. This, of course, it did not do, being, if anything, closer to punishment than was the influence of the blanks

The failure of the medium to account for the lesser influence of punishment in the case of the weak connections may be due to

1. an inadequate representation of the medium,

2 lack of any influence on the part of the medium,

3. the masking of the medium by the "sense of relief" factor discussed above

Summary and Conclusions

From an experiment in which the essential features of Thorndike's vocabulary learning experiments were duplicated (but certain details altered), results appear which indicate

1 that with reference to all connections taken together reward strengthens and punishment weakens connections;

2. that, with reference to weak connections only, the influence of punishment appears much less marked, but is still suggested.

The difference between these results and those reported by Thorndike may be due to

1 the difference in the details of procedure (especially with regard to length of tests),

2 the fact that Thorndike used only weak connections,

3 the fact that the influences of punishment and reward were measured from different base lines in the two experiments [chance expectancy (20%) in Thorndike's and an empirical control (36%) in mine]

References

1 Stephens, J M. The influence of punishment on learning *J. Exper. Psychol*, 1934, 17, 536-555.

2. Thorndike, E L Fundamentals of learning. New York: Bur Publ Teach. Coll, Columbia Univ, 1932 Pp xviii + 638.

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A STUDY OF COLOR VISION IN THE MOUSE (*MUS MUSCULUS* L) AND THE HOUSLIK (*CITELLUS CITELLUS* L)

GÁBOR KOLOSVÁRY

In this paper are presented observations and experiments which contribute to our knowledge of the color sense in animals

EXPERIMENTS WITH MICE

The experimental box used in this study was divided into two sections, the first consisting of a food box and a passage-way which led into the second section, a smaller compartment which contained the nests. The original nests, which were made of straw, were removed and in the passage-way were placed strips of paper for the animals to use in reconstructing their nests

Two hundred and twenty strips of paper, each approximately 20 cm long and 1 cm wide, were furnished, 110 white, and 10 of each of the following 11 colors purple, red, rose, bright rose, orange, yellow, brown, bright brown, green, blue, and bright blue.

The animals were given seven opportunities to rebuild their nests, the number of white and colored strips being recorded each time and the nests destroyed. At the first such opportunity 44 white and 8 colored strips were used Upon the destruction of the nests constructed of these strips, the animals carried away only 3 white and 2 colored strips Deprived of these, they again carried away only a few strips. When these were removed a period of increased activity ensued in which all the strips were carried into the nesting compartment. However, only 36 white and 12 colored strips were used in the actual construction of the nests In the next experiment 10 white and 11 colored strips were utilized, in the sixth

TABLE 1

NUMBER OF STRIPS OF EACH COLOR USED IN EACH OF THE SEVEN RECONSTRUCTIONS OF THE NESTS

Color	No of strips presented	No. of strips used in each reconstruction of nests							No of strips remaining
		1	2	3	4	5	6	7	
White	110	44	3	5	36	10	12	16	4
Purple	10								10
Red	10	1			1		3	1	4
Rose	10					2	2	1	5
Bright rose	10	1	1		1	2	2	3	0
Orange	10						1		9
Yellow	10						2	2	6
Brown	10				1	2	3	4	0
Bright brown	10	1			1		8		0
Green	10				2		4	4	0
Blue	10	1			2	5	2		0
Bright blue	10	4	1	1	4				0

experiment, 12 white and 27 colored strips were carelessly put together in the nesting compartment; and in the seventh trial, the animals still more carelessly and hesitatingly carried away 16 white and 15 colored pieces From the material remaining after this trial—4 white and 34 colored strips—they refused to make nests, but cowered in the corner of the box.

Table 1 gives the results of the seven experiments just described. From the data presented in this table it appears that the mice showed a distinct preference for the white strips, since they left but 4 of these as compared to 34 colored ones. Among the colors, it appears that they favored the bright blue more than any other, while purple and orange were the least favored Brown, green, and blue were decidedly favored when contrasted with the choices of red and yellow, the former being all carried away, while the latter were practically all left at the end of the experiments. It should be noted that it was only after the fifth choice, when the bright blue strips and a goodly proportion of the white strips had been carried away, that the other colors were taken Finally, it is interesting to note that the bright tints were chosen in preference to the darker ones

Experiments with a Souslik

Only one animal was available for these experiments The original nest was not disturbed, but 20 strips of white and 20 of blood-red paper, slightly larger than those used in the experiments with the mice, were strewn about the cage. The strips chosen were not removed from the cage but were taken from the nest and strewn about the cage after each experiment. Eleven experiments were made

TABLE 2

Number of Red and White Strips Used by Souslik in Each of the Eleven Experiments

No. of experiment	No. of white strips used	No of red strips used	Totals White	Totals Red
1	10	9		
2	7	5		
3	14	4	31	18
4	16	6		
5	20	15		
6	3	5		
7	20	18	59	44
8	16	8		
9	20	20		
10	20	19		
11	9	16	65	63

Table 2 presents the choices made by the animal. In the first experiments the choices seem to be made in favor of the white strips, 31 white and 18 red strips being chosen in the first three experiments, and 59 white

and 44 red in the next four. After the ninth experiment, however, it appears that the animal has become habituated to the red pieces and makes ready use of them

Following the experiments with the red and white strips, 30 white, 30 black, and 30 bright blue strips were placed in the cage with the souslik At its first opportunity for choice the animal carried away 8 white, 9 black, and 16 blue strips. The second time, 10 white, 10 black, and 17 blue were chosen; the third time, 25 white, 26 black, and 30 blue; and the fourth time, all 90 strips were taken. It appears, therefore, that white and black were of approximately equal value to the animal, while blue was quite decidedly favored in comparison with either

The next experiment utilized red, white, and blue Twenty strips of each color were used Table 3 shows the choices made from these three colors

TABLE 3

NUMBER OF RED, WHITE, AND BLUE STRIPS USED BY SOUSLIK IN EACH OF THE SIX EXPERIMENTS

No of experiment	No of red strips used	No of white strips used	No. of blue strips used
1	8	8	16
2	8	19	19
3	7	17	20
4	8	16	18
5	9	16	20
6	7	8	15

It is evident that blue was chosen more than either of the other two and that red was the least favored

SIGNIFICANCE OF THE EXPERIMENTAL RESULTS IN THE LIGHT OF FORMER STUDIES

There have been a number of investigations of the color sense in animals and it may be interesting at this point to summarize a few of the outstanding findings and to see how the present results fit in with them

Hess and others, on the basis of experimental studies, deny the existence of color vision in the Arthopoda Others, however, feel that the problem is still an open one, that experimental circumstances and methods have been inadequate for its solution. Extensive studies have been carried out with bees, especially by von Buttel Reepen (8) and Bierens de Haan (4) The latter writes "Die Bienen dressieren sich auf die absolute Helligkeit des Dressurpapiers und von einer Dressur auf das Verhaltnis der beiden Graunuancen wie bei den hoheren Tieren, ist keine Spur zu finden"

Frolich studied the problem with Cephalopoda and came to the conclusion that his animals discriminated between red and blue Other in

vestigators, however, explain this discrimination on the basis of brightness differences.

Herder has recently shown that fishes discriminate between different shades of gray and black. Von Frisch reports the same results.

Yerkes' experiments with birds are very well known He secured positive results with his multiple-discrimination boxes Kohler, Katz, Toll, Jaensch, and Riekel found that hens react to color on a relative basis Hopkins (7), working with mice, Guyton (3), with rats, and Wissenburgh and Tibout (10), with guinea pigs, also found that these animals react on a similar basis.

Most interesting, perhaps, are the experiments with monkeys. Dahl (1), working with *Cercopithecus griseoviridis*, showed that this monkey discriminates between red and green and may form associations based on such discriminations Bierens de Haan (4) also found that monkeys make discriminations even between tints of a given color.

From even so short a summary it appears that animals may possess an ability to discriminate not only between colors, but also between differences of brightness in colors, to a degree corresponding to the relative number of rods and cones in their retinas This generalization must be made only tentatively, however, since a great deal more experimental evidence is needed to clear up details

It seems that more detailed knowledge must surely verify the supposition that in the optical apparatus every color is perceived with a separate organ or nerve termination. The color-sensitive cone, known to be present in the retina of man and of all the vertebrates, does not offer a sufficient basis for the satisfactory explanation of all the phenomena of color vision and color blindness. However, it seems certain, as von Buttel Reepen states, "dass die Bienen in gewisser Weise mehr sehen und anders sehen wie wir" This may also be true of animals other than bees Although the human eye is sensitive only to rays of 390 to 760 mμ, there is no evidence that the eyes of other animals possess a sensitivity only for these wave-lengths

The retinas of nocturnal animals, such as the bat, the cat, and the mouse, are supplied with a much greater number of rods than of cones The rods are insensitive to color and mediate only sensations of colorless light. In daylight, on the other hand, the function of the cones increases in importance since the mediate sensations of color.

Since green and blue, i e., colors of shorter wave-length, stimulate the rods, and since, as we have pointed out, the retinas of mice are well supplied with these receptors, the choice of blue and white by the mice seems quite natural. On the other hand, red has little stimulating value for the rods, and papers of this color were seldom chosen by the animals

Evidence from the other experimenters whom I have mentioned and from the experiments here reported seems to indicate that colors, especially

bright colors and their tints, may be distinguished by animals This may not mean that single colors are perceived as such (perhaps because of the few cones present), but it does show that there is a "feeling of difference," i e, discrimination, even in animals whose retinas are copiously supplied with rods

SUMMARY

In summary, by a trainingless procedure we have shown that the mouse shows a preference for white and bright colors when given a choice between these and darker colors. It also discriminates between the blue and red color-groups of the spectrum, i e., between shorter and longer wave-lengths, preferring the blue

The souslik, being a daylight animal, probably possesses more cones, it made no distinction between black and white as far as its choice of strips was concerned On the other hand, it did distinguish between red and blue, preferring the blue more than any other color

REFERENCES

1. DAHL, F Versuche uber den Farbensinn einer Meerkatze *Zool Jahrb, Abt Syst*, 1907, 25
2. FISCHEL, W Methoden zur psychologische Untersuchungen der Wirbeltiere *Abderhaldens Hdbh d. Biol Arbeithsmeth*, 1932, Abt 6, T. D., 233-338
3. GAYTON, A H The discrimination of relative and absolute stimuli by albino rats *J. Comp Psychol*, 1927, 7, 93-106.
4. BIERENS DE HAAN, J. A Ueber Wahl nach relativen und absoluten Merkmalen Versuche an Affen und Bienen. *Zsch. f vergl Physiol*, 1928, 7, 425-487
5. HELSON, H. Insight in the white rat *J Exper Psychol.*, 1927, 10, 278-296.
6. HERTER, K Dressurversuchen an Fischen *Zsch. f vergl Physiol.*, 1929, 10, 688-711
7. HOPKINS, A. E Experiments on color vision in mice in relation to the duplicity theory. *Zsch f vergl Physiol*, 1927, 6, 299-344.
8. REEPEN, v B Die Farbenblindheit der Bienen *Munch med. Woch*, 1916, 22.
9. ——— Sehen die Bienen fur uns unsichtbare Farben? *Leipziger Bienenzeit*, 1922, Marz.
10. WISSENBURGH, J C, & TIBOUT, P H C Choix basé sur l'aperception complexe chez les cobayes. *Arch néerl de physiol*, 1921, 6, 149-162

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BOOKS

GLADYS C SCHWESINGER *Heredity and Environment* New York, Macmillan, 1933 Pp viii+484 4 00

In a rapidly growing field there is need for frequent consolidation and appraisal of results. Something of this kind occurs, of course, in the "summary of the literature" accompanying almost any Ph D. dissertation, in the general "justification" with which many a published research is prefaced and in the reviews and annotated bibliographies which appear from time to time in the professional periodicals Seldom, however, do such summaries offer the detailed excerpts of original data and the critical synthesis of evidence which would enable the reader-investigator to conclude: "The established points are these The findings are inconclusive upon these other points Further work in the field can profitably take these directions."

For the nature-nurture problem, or at least for certain aspects of it, Miss Schwesinger has essayed an unusually comprehensive evaluation Her volume was prepared "as part of an attempt to appraise the present status of knowledge in the field of eugenic research" The survey is introduced by two chapters on the measurement of intelligence and personality respectively; then comes the main contribution of the book, a summary of research studies upon heredity and environment in relation to intelligence. This is followed by a chapter entitled "Viewpoints on Personality" A chapter of conclusions and an appendix on "Fields of Further Research" complete the work.

The summary of research studies, as one might expect, draws heavily upon the experimental work of the past decade and particularly upon the investigations reported in the 1928 *Yearbook of the National Society for the Study of Education*, and the histories of identical twins reared apart whom Muller and Newman have studied The summary is by no means narrow or one-sided, however. It is documented by over two hundred references, delves back into the pioneer studies of Galton, traces the development of techniques since these early beginnings, and discusses modern investigations at considerable length according to the following classification:

Relation of intellectual resemblance to degree of kinship and variation in general culture

A Heredity similar

B Heredity varied: environment similar

C Influence of specific environmental factors (cultural and physical)

D Animal experimentation.

Essential tabular material from the most significant investigations has been reproduced, and the author herself has compiled a number of useful *summary tables and charts from her combined sources (e.g., correlation* studies of family resemblance, comparison of intra-twin differences of identical and fraternal pairs reared together and identical pairs reared apart, etc.) Her chief conclusions seem to the reviewer fully justified

> The evidence that there are important differences among individuals in hereditary capacity for intelligence is entirely conclusive; the variabilities and averages of large numbers of individuals under influences of varying environments are in *process of being quite accurately determined* And there is strong evidence . that the higher intelligence of the upper socio-economic groups as compared with groups lower in the *socio-economic scale is to an important extent due to differences* in hereditary capacity

In matters of detail, there are several points where questions might be raised as to the author's interpretation of data

Pp 202, 206, 221-224 Discussion of the various statistical techniques *which have been offered for evaluating the contributions of nature and* nurture to twin differences Though adopting a somewhat skeptical point of view toward these techniques, the author has not shown wherein they are deficient (e g, Hirsch's unwarranted subtraction of the unsubtractable mean intra-pair differences of identical twins subtracted from *those of fraternal twins in an attempt to establish the separate effects of* heredity and environment) Neither has the relationship of *intra-twin differences* to *individual differences in the generality* been elucidated. This is an issue much in need of clarification, for it has sometimes been uncritically assumed that establishing the proportional contributions of *nature and nurture to twin differences has very general implications.* The reviewer has elsewhere argued against this assumption, and has pointed out that when differences are relatively slight, as in the case of twin pairs, fixing the relative contributions of heredity and environment is without general interest

P 235 "If . . all parental mates in a group are of pure brown-eyed stock, all the children will be brown-eyed, and the sib correlation will be 1" The fact has been overlooked that a correlation coefficient is an expression of concomitant variability, and that a perfectly homogeneous series of siblings or of parents and offspring would *yield a correlation of* zero.

P. 237 "It may be noted that the coefficient of correlation between natural parent and child is around 3 . " The author's summary table, from which this conclusion is drawn, shows that the parent-child correlations tend to cluster around 45 or 50 *except when unreliable measures are used*

P 259 In discussing the mean intelligence level of the subjects of the

Stanford study of foster children, the author states that the increment of intelligence attributed to superior environment (about 5 points) is insignificant, "as that figure falls rather closely within the normal range of variations on test-retest records" This overlooks the fact that a difference which may be due solely to chance in the test and retest of *individuals* is reliable when it represents the displacement of the mean score of a *group* of several hundred children.

Pp 322, 329. The author compares the I Q's of children having physical handicaps with the I Q's of unhandicapped siblings, and assumes that allowance should be made for sibling regression toward the mean But this would be indicated only if the handicapped children had been *selected* on the basis of I Q Under the circumstances, there is no more reason for minimizing differences by allowing for regression of the siblings than there would be for exaggerating differences by allowing for regression of the handicapped children from the mean of their siblings.

In the chapter on the measurement of intelligence the author prepares the reader for her survey of the nature-nurture literature on intelligence In the chapter on the measurement of personality, she prepares the reader for not including a survey of the nature-nurture literature on personality, taking the view that "the factors underlying personality development are as yet so incompletely understood by psychologists, the tools of measurement so inadequate, the research data so meager and insecure, that we did not feel justified in organizing such an analysis" Instead (in Chapter 5), she has chosen to present "the main points of view, the theories, the various approaches to the study and understanding of personality which have grown up in the fields of psychology and psychiatry"

Is it a reviewer's proper task to comment upon the *Aufgabe*, or should evaluation be restricted to the author's success in following the rules which he himself lays down? Since Poyer's *L'Hérédité Psychologique* (1921) and Peter's *Vererbung geistiger Eigenschaften* (1925) there has been no adequate, critical summary of the nature-nurture literature concerning personality traits, although many would concede this literature to be not so meager and insecure as to be ignored. On the other hand, there have been numerous and recent critiques of methods of measurement, and of viewpoints on personality Whether a somewhat different allocation of space would have resulted in a survey even more useful than the present one, we leave as an unanswered question

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Books Received

BETTS, E A, & BONTRAGER, O. R. Research studies in elementary school language, No 1 An evaluation of certain techniques for the study of *oral composition* (Betts) *An experimental appraisal of pupil control* of certain punction items (Bontrager) *Univ Iowa Stud. Stud. Educ*, 1934, 9, No 2 (New Ser., No 271) Pp 62. $ 50.

BUYTENDIJK, F. J. J Wesen und Sinn des Spiels das Spielen des Menschen und der Tiere als Erscheinungsform der Lebenstriebe. Berlin. Wolff, 1933 Pp 165

CALIVER, A *Secondary education for negroes U S Dept Interior, Off. Educ Bull*, 1932, No 17 (*Nat. Survey Sec Educ, Monog* No 7.) Washington, D C., U. S. Govt. Print Off, 1933. Pp. ix+121 $ 10

CARPENTER, C. R. A field study of the behavior and social relations of howling monkeys *Comp Psychol. Monog*, 1934, 10, No 2 (Serial No. 48) Pp 168 $2.25.

CORNELL, E L, & COXE, W W. A *performance ability scale. examination* manual; individual record blank. Yonkers, N Y. World Book Co., 1934. Pp. iv+88+4 Manual, $1 50; blanks, pkg of 25, $ 90.

ENGELHARDT, F, ZEIGEL, W. H., JR, & BILLETT, R O. Administration and supervision. *U S Dept Interior, Off. Educ., Bull*, 1932, No 17. (*Nat Survey Sec Educ, Monog.* No 11) Washington, D C.: U. S Govt Print Off, 1933 Pp. viii+207 $.15.

FILHO, L Testes A B C para verificação da maturidade necessária à *aprendizagem da leitura e escrita* (*Bibl de Educ.*, Vol 20.) S. Paulo, Caieiras, & Rio de Janeiro Comp Melhoramentos de S. Paulo (n.d.) Pp. 152

FRANCIS, K V., & FILLMORE, E. A. The influence of environment upon the personality of children. *Univ. Iowa Stud. Stud Child Welfare, 1934*, 9, No 2 (New Ser., No. 274) Pp. 71. Paper bound, $ 75, cloth bound, $1 00.

FREEMAN, G LA V Introduction to physiological psychology. New York: Ronald Press, 1934 Pp xviii+579. $4 50.

GOODENOUGH, F. L. Developmental psychology New York & London: Appleton-Century, 1934 Pp. xx+619 $3 00

GUNN, M. A A technique for improving basic skills in English in high school *Univ Iowa Stud. Stud Educ*, 1934, 8, No 7 (New Ser, No 266). Pp. 40 $ 50

HARTSHORNE, C. The philosophy and psychology of sensation Chicago. Univ Chicago Press, 1934. Pp xiv+288. $3.00

KEFSECKER, W W., & SEWELL, F C. Legal and regulatory provisions affecting secondary education *U S Dept. Interior, Off Educ., Bull.*, 1932, No 17 (*Nat Survey Sec Educ, Monog* No 9.) Washington, D C. U S. Govt. Print Off., 1933 Pp vi+114 $ 10.

KEFAUVER, G N, NOLL, V H, & DRAKE, C E. The secondary-school population *U. S. Dept. Interior, Off Educ, Bull*, 1932, No 17 (*Nat Survey Sec Educ, Monog* No 4) Washington, D. C: U S. Govt. Print Off, 1933 Pp viii+58 $10

LOOMIS, A. K., LIDE, E S, & JOHNSON, B L The program of studies. (In two parts) *U S Dept Interior, Off Educ, Bull.*, 1932, No. 17. (*Nat. Survey Sec. Educ, Monog.* No 19.) Washington, D. C Govt. Print Off, 1933 Pp x+340 $15

MURSELL, J. L A workbook in principles of education New York. Norton, 1934 Pp iv+140 $1 25

———. Principles of education New York Norton, 1934 Pp xii+505 $2 75.

NATIONAL COUNCIL FOR THE SOCIAL STUDIES (DEPARTMENT OF SOCIAL STUDIES OF NATIONAL EDUCATION ASSOCIATION) Fourth yearbook. the social-studies curriculum, 1934. Philadelphia McKinley, 1934. Pp. 227. $2 00

PERL, R E The effect of practice upon individual differences *Arch Psychol*, 1934, 24, No. 159 Pp. 54

THORNDIKE, E. L, WATERS, R. H, STONE, C. P, MOSS, F. A., PURDY, D M., FIELDS, P. E, FRANZ, S. I, LIDDELL, H S, HERON, W. T, TOLMAN, E C., TRYON, R. C., & TINKLEPAUGH, O. L Comparative psychology. (Ed. by F. A Moss) New York Prentice-Hall, 1934. Pp xiv+529. $3 50.

TUTTLE, H S. A social basis of education. New York Crowell, 1934. Pp x+589. $3 00

WARDEN, C J., JENKINS, T. N., & WARNER, L H Introduction to comparative psychology New York. Ronald Press, 1934. Pp x+581 $4 50

ZNAMENSKY, G. E New key to ourselves. Boston: Author, 1934 Pp vi+75. $1 00

SUBJECT INDEX

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